



PHD

**Exploring Creativity in Temporary Virtual Teams
The Case of Engineering Design**

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Exploring Creativity in Temporary Virtual Teams: The Case of Engineering Design

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A thesis submitted for the degree of Doctor of Philosophy

University of Bath
Department of Mechanical Engineering
in co-supervision with the School of Management

April 2014

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Table of Contents

LIST OF FIGURES.....	VIII
LIST OF TABLES	X
ACKNOWLEDGEMENTS	XI
THESIS RESEARCH OUTPUT*	XIII
REFEREED JOURNAL ARTICLES	XIII
CONFERENCE CONTRIBUTIONS (PEER-REVIEWED)	XIII
INVITED PRESENTATIONS.....	XIV
DOCTORAL CONSORTIA.....	XIV
ABSTRACT.....	XV
LIST OF ACRONYMS.....	XVI
CHAPTER 1: INTRODUCTION	1
1.1 BACKGROUND AND KNOWLEDGE GAP	1
1.2 PERSONAL MOTIVATION	5
1.3 RESEARCH AIM AND CLARIFICATIONS	6
1.4 EMPIRICAL CONTEXT, RESEARCH QUESTION AND APPROACH	8
1.5 RESEARCH ORGANIZATION	10
1.6 STRUCTURAL BODY OF THE THESIS	11
CHAPTER 2: VIRTUAL TEAM LITERATURE.....	12
2.1 UNDERSTANDING AND CONCEPTUALIZING VIRTUALITY	12
2.2 SITUATING VIRTUAL TEAMS WITHIN THE VIRTUALITY LITERATURE	14
2.3 VIRTUAL TEAMS: PERSPECTIVES AND DEFINITIONS.....	16
2.4 TYPOLOGIES OF VIRTUAL TEAMS.....	18
2.5 VIRTUAL TEAM PROCESS AND LIFECYCLE	23
2.6 BENEFITS OF VIRTUAL TEAMS.....	28
2.7 INDUSTRIAL EXAMPLES OF VIRTUAL TEAMS	31
2.8 CHALLENGES OF VIRTUAL TEAMS.....	33
2.9 TECHNOLOGY AND VIRTUAL TEAMS	40
2.10 VIRTUAL TEAMS IN ENGINEERING DESIGN: VIRTUAL DESIGN TEAMS.....	46
2.11 SUMMARY OF THE VIRTUAL TEAM LITERATURE	49

CHAPTER 3: CREATIVITY LITERATURE	50
3.1 CREATIVITY LITERATURE: ETYMOLOGY AND DEFINITIONS	50
3.2 SIGNIFICANCE OF CREATIVITY	53
3.3 TYPES AND FRAMEWORKS OF CREATIVITY	55
3.4 THE THREE LEVELS OF CREATIVITY	58
3.4.1 <i>Individual Creativity</i>	58
3.4.2 <i>Team Creativity</i>	60
3.4.3 <i>Organizational Creativity</i>	63
3.5 CREATIVITY IN ENGINEERING DESIGN.....	66
3.6 SUMMARY OF THE CREATIVITY LITERATURE	70
CHAPTER 4: THEORETICAL FRAMEWORK AND RESEARCH QUESTION	71
4.1 CREATIVITY IN VIRTUAL TEAMS: WHAT DO WE KNOW?	71
4.2 GAPS IN OUR UNDERSTANDING OF CREATIVITY IN VIRTUAL TEAMS	78
4.3 PUTTING THE PIECES TOGETHER: THEORETICAL FRAMEWORK AND RESEARCH QUESTION.....	82
4.4 ONWARD	86
CHAPTER 5: RESEARCH APPROACH	87
5.1 RESEARCH STANCE: PHILOSOPHY OF SCIENCE AND PARADIGMS	87
5.1.1 <i>Positivism</i>	89
5.1.2 <i>Critical Realism</i>	90
5.1.3 <i>Interpretivism</i>	91
5.2 METHODOLOGY AND IMPLICATIONS.....	94
5.3 RESEARCH STRATEGY: CASE STUDY	100
5.4 DATA COLLECTION METHODS	107
5.4.1 <i>Interviews</i>	108
5.4.2 <i>Observations and Visual Data</i>	109
5.4.3 <i>Documents, Design Outputs, and Communication Extracts</i>	112
5.5 DATA ANALYSIS METHODS	113
5.5.1 <i>Visual Analysis</i>	113
5.5.2 <i>Thematic Analysis</i>	116
5.6 THE THREE CASE STUDIES: SIMILARITIES AND DIFFERENCES	120
5.6.1 <i>Brief Presentation of Case Study 1—the EGPR</i>	120
5.6.2 <i>Brief Presentation of Case Study 2—ESTIA24</i>	122
5.6.3 <i>Brief Presentation of Case Study 3—A Comparative Case Study in Industry</i>	124
5.8 ONWARD	127

CHAPTER 6: CASE STUDY 1—THE EGPR	128
6.1 RESEARCH SITE: THE EGPR	128
6.1.1 <i>The EGPR Organization</i>	132
6.1.2 <i>The EGPR Suitability</i>	134
6.2 THE VDTs UNDER INVESTIGATION	135
6.2.1 <i>The EGPR Participants</i>	135
6.2.2 <i>Methods of Communication</i>	136
6.2.3 <i>Subgrouping in Team Formation</i>	137
6.3 DATA COLLECTION PROCESS	138
6.4 DATA ANALYSIS PROCESS	141
6.5 ANALYSIS AND FINDINGS	143
6.5.1 <i>Presentation of the teams</i>	143
6.5.2 <i>Creativity Fluctuation during the EGPR Design Process and VDT Lifecycle</i>	145
6.5.3 <i>Examples of High Creativity in the EGPR</i>	151
6.5.4 <i>Analysis of the Factors Influencing VDT Creativity</i>	153
6.6 REFLECTION ON, AND STRENGTHS OF, STUDY 1.....	167
6.7 ONWARD	168
CHAPTER 7: CASE STUDY 2—ESTIA24	169
7.1 RESEARCH SITE: ESTIA24	169
7.1.1 <i>ESTIA24 Organization</i>	170
7.1.2 <i>ESTIA24 Suitability</i>	171
7.2 THE VDT UNDER INVESTIGATION.....	173
7.2.1 <i>The ESTIA24 Participants</i>	175
7.2.2 <i>The Design Task</i>	176
7.2.3 <i>Geographical Dispersion and Location</i>	177
7.2.4 <i>Methods of Communication</i>	178
7.3 DATA COLLECTION PROCESS	179
7.3.1 <i>Collection of Video Recordings</i>	181
7.3.2 <i>Collection of Written Outputs</i>	182
7.3.3 <i>Collection of Interview Data</i>	183
7.4 DATA ANALYSIS PROCESS	185
7.4.1 <i>Analysis of Video Recordings and Design Outputs</i>	185
7.4.2 <i>Analysis of Video Recordings and Interview Data</i>	187
7.5 ANALYSIS AND FINDINGS	189

7.5.1 The 24h-long Design Process and VDT Lifecycle: An Overview.....	189
7.5.2 Illustrative Story: A Mountain-shaped Desk Tidy.....	196
7.5.3 Management Issues Influencing Creativity.....	199
7.5.4 Task and Individual: Core Factors Influencing VDT Creativity	207
7.5.5 Creativity and the Unique Characteristics of Virtuality	211
7.6 REFLECTION ON, AND STRENGTHS OF, STUDY 2.....	223
7.7 ONWARD	224
CHAPTER 8: CASE STUDY 3—A COMPARATIVE CASE STUDY IN INDUSTRY	225
8.1 THE RESEARCH SITE.....	225
8.1.1 Alpha—The Organization	225
8.1.2 Alpha’s Suitability	226
8.2 THE TEAM UNDER INVESTIGATION	228
8.2.1 The Face-to-Face Project.....	230
8.2.2 The Virtual Project	230
8.3 DATA COLLECTION PROCESS	234
8.4 DATA ANALYSIS PROCESS	237
8.4.1 Analysis of Interview Data	237
8.4.2 Analysis of Video Recordings and Communication Outputs.....	239
8.5 ANALYSIS AND FINDINGS	240
8.5.1 The F2F Project: A Man Overboard Recovery Device.....	240
8.5.2 The Virtual Project: A Double Glazed Sash Window	254
8.5.3 Synthesis of Findings from the two Components.....	278
8.6 REFLECTION ON, AND STRENGTHS OF, STUDY 3.....	281
8.7 ONWARD	282
CHAPTER 9: DISCUSSION	283
9.1 A TYPOLOGY OF THE THESIS’ VIRTUAL DESIGN TEAMS.....	283
9.2 THEORETICAL CONTRIBUTIONS	286
9.2.1 Understanding Creativity within the VDT Lifecycle.....	286
9.2.2 Elicitation of Factors influencing Creativity in Temporary VDTs.....	293
9.2.3 Creativity and the Unique Characteristics of Virtuality	302
9.3 ONWARD	316
CHAPTER 10: CONCLUSION	317
10.1 SYNOPSIS OF THE THESIS	317
10.2 LIMITATIONS	320

10.3 IMPLICATIONS FOR RESEARCH	322
10.4 IMPLICATIONS FOR PRACTICE	326
REFERENCES	329
APPENDICES	364
APPENDIX A: EGPR FIRST CONTACT AND APPROVAL EMAIL EXCERPT	364
APPENDIX B: EGPR NON-DISCLOSURE AGREEMENT (NDA) FORM.....	365
APPENDIX C: ESTIA24 WEBSITE LINKS	367
APPENDIX D: PARTICIPANTS' ETHICS AND CONSENT FORMS	368
APPENDIX E: COMMUNICATIONS WITH ESTIA24 LEAD ORGANIZER.....	369
APPENDIX F: ESTIA24 MANUAL CODING OF VDT LIFECYCLE AND IDEAS	370
APPENDIX G: VISUAL ANALYSIS OF STUDIES 2 AND 3	371
<i>Study 2 Visual Analysis</i>	371
<i>Study 3 Visual Analysis</i>	372
APPENDIX H: COLOURS EXPLAINING APPENDIX G	373

List of Figures

Figure 1: Research Organization Steps and Rationale	10
Figure 2: Levels of Virtuality Research (after Panteli, 2009, p. 2).....	14
Figure 3: A Typology for Virtual Teams (after Panteli, 2004b, p. 28).....	19
Figure 4: Dimensions of Virtualness (after Griffith <i>et al.</i> , 2003, p. 267).....	21
Figure 5: Virtual Team Process (after Powell <i>et al.</i> , 2004, p. 8)	23
Figure 6: Virtual Team Lifecycle Phases and Activities (after Hertel <i>et al.</i> , 2005, p. 73) ..	26
Figure 7: ICTs per Synchronicity and Purpose (after Smith and Blanck, 2002, p. 299)	41
Figure 8: Team Diversity and Commonality of Ideas (after Elias <i>et al.</i> , 2011, p. 626)	48
Figure 9: Relationship between Creativity and Innovation (after e.g. West, 2002)	52
Figure 10: Matrix of Creativity Types (after Unsworth, 2001, p. 291)	55
Figure 11: Three Levels of Creativity (after Chen, 2006; Thatcher and Brown, 2010).....	57
Figure 12: Factors Influencing Creativity in Asynchronous Virtual Teams (after Ocker, 2007b, p. 41); + = enhancers, - = inhibitors.....	74
Figure 13: Understanding Creativity in VDTs: A Theoretical Framework.....	82
Figure 14: Observation Continuum (after Junker, 1960; Kawulich, 2005)	110
Figure 15: Excerpt of Observations/Video Analysis in Spreadsheet (Colour coding is explained in Appendix H)	115
Figure 16: The Scope of the EGPR (after Horvath <i>et al.</i> , 2003, p. 85)	129
Figure 17: Main Aims of EGPR (Kovacevic, 2008, p. 1384)	130
Figure 18: The EGPR Map for the Academic Year 2009/2010	131
Figure 19: Phase 4 Structure and Guidelines (document extract)	132
Figure 20: VC Lecture from a Previous Year (document extract)	136
Figure 21: Detailed Data Collection Steps	138
Figure 22: Creativity in the EGPR Lifecycle	145
Figure 23: Teams working F2F during Phase 4 (photographic data).....	149
Figure 24: The ESTIA24 Mindmap (ESTIA24 website)	170
Figure 25: The Two Geographically-dispersed Subgroups	173
Figure 26: The Design Task: An Eco-citizen Object (document extract)	176
Figure 27: The Two Subgroups together on the VC (video data)	178
Figure 28: Analysing the Task Early on in the VDT Lifecycle (photographic data)	190
Figure 29: Performing Brainstorming in the UK Site (photographic data)	192
Figure 30: An Unorganized Representation of the 24h-long ESTIA24 VDT Ideas.....	193
Figure 31: Creativity in the 24h-long VDT Lifecycle (after Excel in Appendix G).....	195

Figure 32: A Mountain-shaped Desk Tidy (photographic data).....	196
Figure 33: Six Ideas during the ESTIA24 from the UK Subgroup (photographic data)..	197
Figure 34: Hourglass Idea on CAD (photographic data)	198
Figure 35: Post-it Bin Idea (photographic data).....	198
Figure 36: Acting-out Concept's Functions due to Language Issues (video data)	201
Figure 37: Geographical Dispersion in the Industrial VDT	231
Figure 38: VDT Collaboratively Organizing Work on Prezi (photographic Data)	233
Figure 39: Progress Exploiting Wall Space	245
Figure 40: An Unorganized Representation of the VDT Ideas	257
Figure 41: Creativity in the VDT Lifecycle (after Excel in Appendix G)	258
Figure 42: An Emergent VT Typology highlighting the VDT Context of the Thesis	283

List of Tables

Table 1: Definitions of Virtual Teams.....	16
Table 2: Interventions during the Virtual Team Lifecycle (Furst <i>et al.</i> , 2004, p. 15)	25
Table 3: Benefits of Virtual Teams (after Ebrahim <i>et al.</i> , 2009, p. 2657)	29
Table 4: Focus of the Virtual Team Literature.....	42
Table 5: Definitions of Creativity	51
Table 6: Elements Used to Measure Creativity (after Cropley, 2000, p. 77).....	68
Table 7: The Two Paradigms	88
Table 8: Case Study Research Strengths (after Gable, 1994, p. 11)	104
Table 9: Data Collection Methods in Case Study Research (after Yin, 2008, p. 80).....	107
Table 10: Open and Axial Codes emerging from Thematic Analysis.....	118
Table 11: The Main Characteristics of the Three Case Studies.....	126
Table 12: The EGPR Phases.....	133
Table 13: Presentation of Teams and Interview Data Collected.....	143
Table 14: Leadership Styles Influencing VDT Creativity.....	160
Table 15: Factors Influencing VDT Creativity in the EGPR	166
Table 16: Presentation of the ESTIA24 University A Participants	175
Table 17: Detailed Data Collection Table.....	179
Table 18: Management Issues Influencing Creativity in ESTIA24	199
Table 19: Factors Influencing VDT Creativity in ESTIA24.....	220
Table 20: Presentation of the Industrial Team Participants.....	228
Table 21: Detailed Data Collection Table.....	234
Table 22: Management Issues Influencing Creativity in Study 3 VDT	262
Table 23: Factors Influencing Creativity in the Industrial Case Study	279
Table 24: Creativity in the VDT Lifecycle.....	292
Table 25: Factors Influencing Creativity in temporary VDTs*	299
Table 26: Virtuality-related Factors Influencing Creativity in temporary VDTs*	311
Table 1: Factors relating to the Design Context.....	315

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CHAMAKIOTIS, P., DEKONINCK, E.A. and PANTELI, N. 2011. The Creativity of Virtual Design Teams: An Exploratory Case Study. In: *Proceedings of the 6th Mediterranean Conference on Information Systems (MCIS '11): IS: Crossroads of Technology, People, Organizations and Markets*, September 3-5, Limassol, Cyprus.

CHAMAKIOTIS, P. 2011. Factors Influencing Creativity in Virtual Design Teams. In: *Poster Session and Booklet of ASME 2011 International Design Engineering Technical Conferences (IDETC) and Computers and Information in Engineering Conference (CIE)*, August 28-31, Washington DC, USA.

CHAMAKIOTIS, P., DEKONINCK, E.A. and PANTELI, N. 2010. Creativity in Virtual Design Teams. In: *Proceedings of the 11th International Design Conference (DESIGN '10)*, May 17-20, Dubrovnik, Croatia.

Invited Presentations

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CHAMAKIOTIS, P. 2013. Creativity in Virtual Design Teams. In: *The University of Bath Faculty of Engineering and Design Research Students Showcase*, April 18, Bath, UK.

CHAMAKIOTIS, P. 2011. Creativity in Virtual Design Teams. In: *The London School of Economics Seventh Social Study of Information Technology (SSIT) Open Research Forum*, March 29-30, London, UK.

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Abstract

The prevalence of Virtual Team (VT) configurations in organizations has come to challenge the relevance of traditional management practices based on traditional, physically collocated teams. Creativity—a topical and multidisciplinary issue—has been under-researched within the context of virtuality. Predicated on the premise that creativity may be expressed differently in the context of VTs, I draw the conceptual foundations for this research from the fields of virtuality (i.e. VTs) and creativity, and use engineering design as the empirical context, with the aim of pursuing a better understanding of creativity in relationship with virtuality in the context of Virtual Design Teams (VDTs). Design constitutes a pertinent empirical context because (a) designers have to deliver outputs requiring creativity; and (b) their work is increasingly accomplished in VDT environments.

I report on the findings from three case studies involving temporary VDTs. Studies 1 and 2 comprised student engineers. Study 3 was a comparative case study focusing on a team of professional engineers, who completed one design task while physically collocated (face-to-face, F2F) and another one while geographically dispersed (virtually), with the aim of isolating factors that are unique to virtuality. With an interpretive stance guiding this research, the same analytical approach for each case study, and with the team serving as the unit of analysis, I analysed the collected data (interview data, observations, video recordings, photographic material, documents, communication extracts, design and other outputs) qualitatively with the use of visual and thematic analysis.

The thesis makes the following theoretical contributions: (a) it advances understanding of creativity within the VDT lifecycle; (b) it elicits factors influencing creativity in the temporary VDT context; and (c) it explains how the unique characteristics of virtuality influence creativity within this context. The thesis' limitations as well as implications for research and practice are also discussed.

List of Acronyms

Acronym	Term*
CAD	Computer-Aided Design
CMC	Computer-Mediated Communication
CSCW	Computer-Supported Cooperative Work
EGPR	European Global Product Realization
ESTIA24**	ESTIA 24 hours of Innovation
F2F	Face-to-Face
GSS	Group Support System
GVT	Global Virtual Team
ICTs	Information and Communication Technologies
IM	Instant Messaging
IS	Information Systems
PDT	Partially-Distributed Team
RQ	Research Question
SME	Small- and Medium-sized Enterprise
SSIS	Social Study of Information Systems
VC	Video-Conferencing
VDT	Virtual Design Team
VT	Virtual Team

** The terms are provided in full the first time they are mentioned in each chapter*

*** Abbreviation (not an acronym)*

Chapter 1: Introduction

In this chapter, I present the *thesis* of this work, which centres on creativity in the context of temporary Virtual Design Teams (VDTs). I commence the chapter by providing background information on this multidisciplinary topic of research, drawing predominantly from the literatures on virtuality and creativity. I synthesize existing literature that points toward a knowledge gap which—along with my personal motivation—constituted the main driver for this study. I subsequently present the research aim, empirical context, Research Question (RQ) and objectives, and approach, and I close the chapter by outlining how the thesis is organized.

1.1 Background and Knowledge Gap

There exists a growing body of literature surrounding the deployment, implications and management of Virtual Teams (VTs) in organizations. The literature on the Social Study of Information Systems (SSIS), as well as the organizational and general management literatures agree that VTs comprise individuals who are geo-temporally separated from one another and come together through the use of various Computer-Mediated Communication (CMC) channels to accomplish a common task (e.g. Cascio, 2000; Kayworth and Leidner, 2000; Lipnack and Stamps, 1997). Despite some common characteristics emanating from the definition above (e.g. geographical separation), not all VTs are the same; they differ in numerous aspects, e.g. their degree of virtuality (Griffith *et al.*, 2003). The VT literature offers several models that have been used to classify VTs based on these differentiating elements. Further, recent literature has taken the view that the focus should not be on VTs *per se*, but rather on virtuality in teams, highlighting that most teams nowadays combine virtual and Face-to-Face (F2F) modes of communication and that we rarely encounter teams whose members are always physically collocated (e.g. Dixon and Panteli, 2010).

VTs have emerged as a popular and pervasive organizational structure because they typically bring together expertise which is dispersed across different geographical locations; and because they can exploit time differences, thus breaking geographical,

temporal, and other boundaries which have traditionally been found to limit organizations (e.g. Bell and Kozlowski, 2002). It is for this reason why most staff of prominent, global corporations, such as Intel Corporation, work in VTs (Nunamaker Jr *et al.*, 2009). However, the study of VTs is largely grounded on the premise that alongside some unparalleled opportunities come a number of challenges. These challenges are owed to the unique characteristics of virtuality, for example geographical separation and computer mediation, and may include developing trust (Bierly III *et al.*, 2009; Coppola *et al.*, 2004; Dennis *et al.*, 2011; DeRosa *et al.*, 2004; Jarvenpaa *et al.*, 1998; Jarvenpaa and Leidner, 1999; Nandhakumar and Baskerville, 2006; Panteli, 2004b; Panteli and Duncan, 2004; Panteli and Tucker, 2009); and exercising leadership pertinently (Avolio *et al.*, 2000; Bell and Kozlowski, 2002; Carte *et al.*, 2006; Cascio and Shurygailo, 2003; Chamakiotis and Panteli, 2010; Hoyt and Blascovich, 2003; Kayworth and Leidner, 2002; Kerber and Buono, 2004; Ocker *et al.*, 2009a; Zhang and Fjermestad, 2006; Zigurs, 2003); two challenges that—over the last decade or so—have attracted noteworthy academic attention.

These studies assume that the unique characteristics of virtuality call for an alternative approach to developing trust or exercising leadership in the context of VTs. Not surprising, therefore, and as it is common within the SSIS research literature, scholars who have looked into these issues have borrowed selected theoretical concepts from the social sciences (e.g. the psychology and organizational literatures)—which Klein and Myers (1999) argue constitute a sensitizing device—to understand the use, management and implications of Information Systems (IS) phenomena (Avgerou, 2000). For instance, Light (2007) uses concepts from the field of gender studies to explain IS phenomena, in particular relating to the development and use of online social networks. Similarly, Panteli and Duncan (2004) espouse the dramaturgical perspective emanating from Goffman's (1959) impression management theory from the field of social anthropology to explain how trust develops in a VT environment. As such, IS scholars have borrowed concepts from the organizational literature on leadership to understand how new models of e-leadership emerge in a VT environment. The topics that have been investigated in the context of VTs are not limited to trust and leadership though; current scholarship

has also addressed such other topics as technology use (Clear, 2008; Han *et al.*, 2011; Sivunen and Valo, 2006); conflict and emotion (Ayoko *et al.*, 2011; Kankanhalli *et al.*, 2007); and presence and silence (Panteli, 2004a; Panteli and Fineman, 2005); among others. However, the topic of creativity—one of multidisciplinary significance in an era of a globalization and *boundarylessness* (e.g. Andriopoulos and Dawson, 2009)—has not received the attention it deserves within the VT literature. In this thesis, I discuss selected concepts from this literature (i.e. the individual-team-organizational framework) with the aim of advancing IS literature on VTs.

Creativity constitutes a well-researched topic and it is of multidisciplinary value. Early research into creativity was essentially guided by the view that certain individuals are more creative than others, and sought to identify what makes the creative individual. These widely cited studies (e.g. Guilford, 1950; Kirton, 1994; Sternberg, 1999; Torrance, 1965) contribute significant accounts of individual creativity. They identify the dimensions (e.g. capacity, style, approach) along which individuals can produce creative outcomes, and argue that *all* individuals have the potential to be creative—but in different domains. Over time, however, the emphasis shifted from the individual level of creativity research to the team (Kurtzberg and Amabile, 2001; West, 1990) and organizational (Amabile, 1996a; Andriopoulos, 2001; Isaksen and Lauer, 2002) levels. These studies argue for the importance of team- and organization-related factors influencing creativity. In addition to teamwork being recognized as important in industry, part of the assumption that drove research into the team level of creativity was that the more the people, the better the quantity and quality of the ideas (e.g. West, 1990). Numerous scholars have shown that a collaborative team environment is indeed conducive to creativity, but this view is one that has received substantial criticism too (e.g. Staw, 2009). Overall, some of the factors found to influence creativity at the team level are: heterogeneity, diversity, and group composition (Woodman *et al.*, 1993); and at the organizational level: organizational climate, leadership style, organizational culture, resources and skills, and structure and systems of an organization (Andriopoulos, 2001).

However, these findings are made in traditional, physically collocated work environments. Research into creativity in the context of VTs has, to date, been scant. There exist few studies that address creativity in VTs explicitly (e.g. Chang, 2011; Martins and Shalley, 2011; Nemiro, 2007; Ocker, 2005); and other similar studies that have taken a focus on the issue of idea generation in CMC environments (Kerr and Murthy, 2004; Pissarra and Jesuino, 2005). Yet, despite the significance of these studies, discussed systematically in Chapter 4, important knowledge gaps around creativity in VTs continue to exist. For instance, Ocker (2005) and Chang (2011) framed their studies in VT environments in which only asynchronous Information and Communication Technologies (ICTs) were made available to the participants. Thus, these studies consider limited dimensions of the literature on virtuality, for example, by focusing on the issue of asynchronicity and neglecting synchronous VTs. However, important gaps continue to exist; for example, it is unknown whether and how virtuality may influence creativity, or where creativity occurs within the VT lifecycle.

It follows that notable knowledge gaps around VT creativity include the case of VTs using both synchronous and asynchronous ICTs as well as creativity in relationship with the VT lifecycle and the unique characteristics of virtuality.

1.2 Personal Motivation

Following on from the above discussion, which brings to light important knowledge gaps and therefore an academic need to investigate VT creativity, I must also outline the personal reasons that have motivated me to pursue this thesis. First is my curiosity as to how technology has come to impact traditional organizational processes and bring change. This—and the field of the SSIS in particular—is a theme upon which I placed particular emphasis while studying for my MSc in Management and Strategic Information Systems a few years ago. Following my MSc, I worked for a global organization headquartered in Madrid, Spain, where I formed part of numerous VTs myself. It was then when my enthusiasm about VTs paralleled my interest in creativity, which—contrary to that organization’s mission statement and ostensible desire for creativity—was often killed by senior management, since other tasks would oftentimes take priority, and the business focus would be elsewhere. Nine months later, I was employed in the marketing department of a leading European business school, again based in Madrid, where my role involved high degrees of creativity and I was again a member of several VTs simultaneously. In the latter position, creativity was both expected and realized; and it was also high, despite the high degrees of virtuality experienced by the VTs I partook in. Therefore, my urge to pursue research in the area of creativity in VTs developed gradually during my postgraduate studies and my employment in junior management positions at the two highly global organizations I worked for in my post-MSc life.

I have hitherto presented themes that have dominated the VT and creativity literatures which point to significant knowledge gaps, some of which I will be addressing in this thesis. I have also presented the reasons that have led me to the decision to conduct this research. The chapter continues by discussing the aim of this research, by framing the research and ultimately by presenting the RQ.

1.3 Research Aim and Clarifications

The brief introduction in the earlier sections shows that two organizational realities have been posited: (a) the increasing adoption of VTs; and (b) the growing emphasis on creativity by organizations. These underline what constituted this thesis' initial research aim: to explore creativity in the context of VTs, which guided the subsequent comprehensive cross-disciplinary review. Therefore, it was realized that some scholars have begun to investigate empirically creativity in VTs, yet this research was by no means conclusive. Earlier work on creativity in VTs (e.g. Nemiro, 2002; Ocker, 2005) and in VDTs (defined as VTs in the field of design) (Glier *et al.*, 2011), coupled with the limitations characterizing it, formed the basis for the RQ that guided my research and is discussed later.

One of the main criticisms of earlier work on creativity in VTs is that it has neglected the role played by the unique characteristics of virtuality (e.g. geographical dispersion). In view of this, my research seeks to bridge this gap by focusing on the influence exerted by the unique characteristics of virtuality. Therefore, the conceptual foundations of the thesis will be drawn not only from the literature on creativity (e.g. the individual-team-organizational one presented in Figure 11, in Chapter 3)—as other studies have also done—but also from the literature on VTs (i.e. the unique characteristics of virtuality, such as geographical dispersion and computer mediation). These notions are further developed in the following three chapters (Chapters 2-4) and in the theoretical framework (Figure 13, Chapter 4).

In order to frame this research, a number of clarifications are necessary. First, creativity in this thesis is treated as synonymous to idea generation (e.g. Amabile, 1996a; Paulus and Yang, 2000). No method has been developed herein to assess the novelty or usefulness of the generated ideas, other than the perceptions of the participants in the three case studies that were conducted; hence, the focus is on the generated ideas only.

What is more, the notions of creativity and innovation should not be conflated. Creativity is about generation of original ideas which might, or might not, at a later stage, lead to innovation (Amabile, 1988); innovation, on the other hand, concerns

the implementation of such ideas into marketable products (Kristensson *et al.*, 2002; Prahalad and Ramaswamy, 2003). Therefore, this thesis is concerned with creativity, while studying innovation is beyond its scope.

Another clarification that must be made is that large part of the literature pertaining to VTs has examined several VT issues and challenges (e.g. trust, cultural diversity) as a means for providing researchers and practitioners a set of suggestions for improving VT performance and effectiveness (e.g. Zakaria *et al.*, 2004). Contrary to these studies, this thesis is interested in creativity only, rendering associations between creativity and performance in VTs beyond its scope.

It is also important to make it explicit that this research is about creativity in VTs. And consistent with other research in the field of the SSIS, I borrow selected theoretical concepts from the literature on creativity to examine creativity within the context of VTs. While, therefore, there exists literature on creativity in contexts wherein ICTs are used (Kerr and Murthy, 2004), thus other computer-mediated contexts, these studies neglect the dynamics of a team and are purely centred on the interactions of individuals. The study of VTs is unique in that it carries certain attributes, for example collaborative goal toward a common target, at times consecutive assignment of different tasks one after the other (insofar as permanent VTs are concerned), geographical dispersion (in most VTs) and others. It is for this reason why I have espoused the team as the unit of analysis in this thesis. Hence, any other constructs used in the analysis (e.g. the individual) are considered in association with the main unit of analysis, the team.

1.4 Empirical Context, Research Question and Approach

Engineering design (henceforth design) has been selected as a pertinent empirical context, following recent VT research (Jarvenpaa and Keating, 2012). Avgerou (2000) also notes that though, most commonly, IS studies are conducted within business schools, they may equally be hosted by computer science departments or engineering faculties, as in the case of this thesis.

Despite the plethora of definitions of design, in this thesis, I see design as a set of activities whereby an idea is transformed into an outcome (Von Stamm, 2003), satisfying certain requirements, given certain constraints (Ralph and Wand, 2009). The rationale behind this selection is twofold: (a) design constitutes a domain in which creativity is required and therefore expected (Bruce and Bessant, 2002); and (b) VDTs feature as a new phenomenon, urging designers to be creative in unprecedented, for them, team configurations (Monalisa *et al.*, 2008), whereby traditional *pen and paper* techniques used to enhance design creativity may be unavailable (Tang *et al.*, 2010). Within the design literature, there exist scholars whose work has taken a focus on such facets of creativity as creative designs (Gero, 2001), assessment of the creativity of design outputs (Shah *et al.*, 2003), the use of creative stimuli in design (Howard *et al.*, 2011), and the creative process and supporting creativity in design (Warr, 2007). There is also emerging design literature on distributed design, or globally dispersed design—in other words in VDT environments—which has looked into the issues of collaboration (Larsson, 2003) and effectiveness (Monalisa *et al.*, 2008). Distilled from the systematic cross-disciplinary literature review was the following RQ and objectives:

How is creativity influenced in temporary Virtual Design Teams (VDTs)?

- ***Objective 1: To understand creativity within the VDT lifecycle;***
- ***Objective 2: To elicit factors influencing creativity in temporary VDTs; and***
- ***Objective 3: To explain how the unique characteristics of virtuality influence creativity***

These are important questions of value to academics not only in the SSIS, but also in kindred fields (e.g. organization studies, management, psychology); and also to practitioners partaking in, or managing, VTs in design and other industries. In Chapter 4, I present the theoretical framework (Figure 13), on which the RQ is based, and I also discuss the three research objectives. The thesis therefore makes theoretical contributions to the field of SSIS. In particular, it informs research literature focusing on VT creativity (Chang, 2011; Letaief *et al.*, 2006; MacGregor and Torres-Coronas, 2007; Martins and Shalley, 2011; Nemiro, 2007; Nemiro, 2001; Nemiro, 2002; Nemiro *et al.*, 2008; Ocker, 2008; Ocker, 2005); the VT lifecycle (Bell and Kozlowski, 2002; Furst *et al.*, 2004; Hertel *et al.*, 2005); as well as the wider literature on virtuality and VTs, by focusing on the case of creativity in temporary VDTs that assemble for a specific purpose and then disassemble with no expectation of future work (Panteli and Dibben, 2001). In addition, given the multidisciplinary character of the thesis, and the inclusion of creativity and design literature in particular, the thesis will also be significant to scholars and practitioners in these fields as well.

Selecting a pertinent research approach to address the above was critical. A qualitative, interpretive approach coupled with case study analysis were considered suitable, given the newness of the topic under investigation and the importance of context in conceptualizing creativity in VDTs (Yin, 2003). Case studies are also suitable because they allow for the use of multiple data collection methods, which has been the case in this thesis, and provide the means for exploring issues surrounding human interactions that may also be applicable within other contexts (Bryman, 1989). Thus, selecting the case study approach enabled a rich understanding of creativity within the VDT context, embracing the VDT participants' perceptions through interviews, my observations through direct non-participant observation and video analysis, as well as analysis of other material, including written communication extracts and design outputs, contributing thereby a rich exploration of creativity within this context.

1.5 Research Organization

I show pictorially the steps and rationale that guided this research (Figure 1).

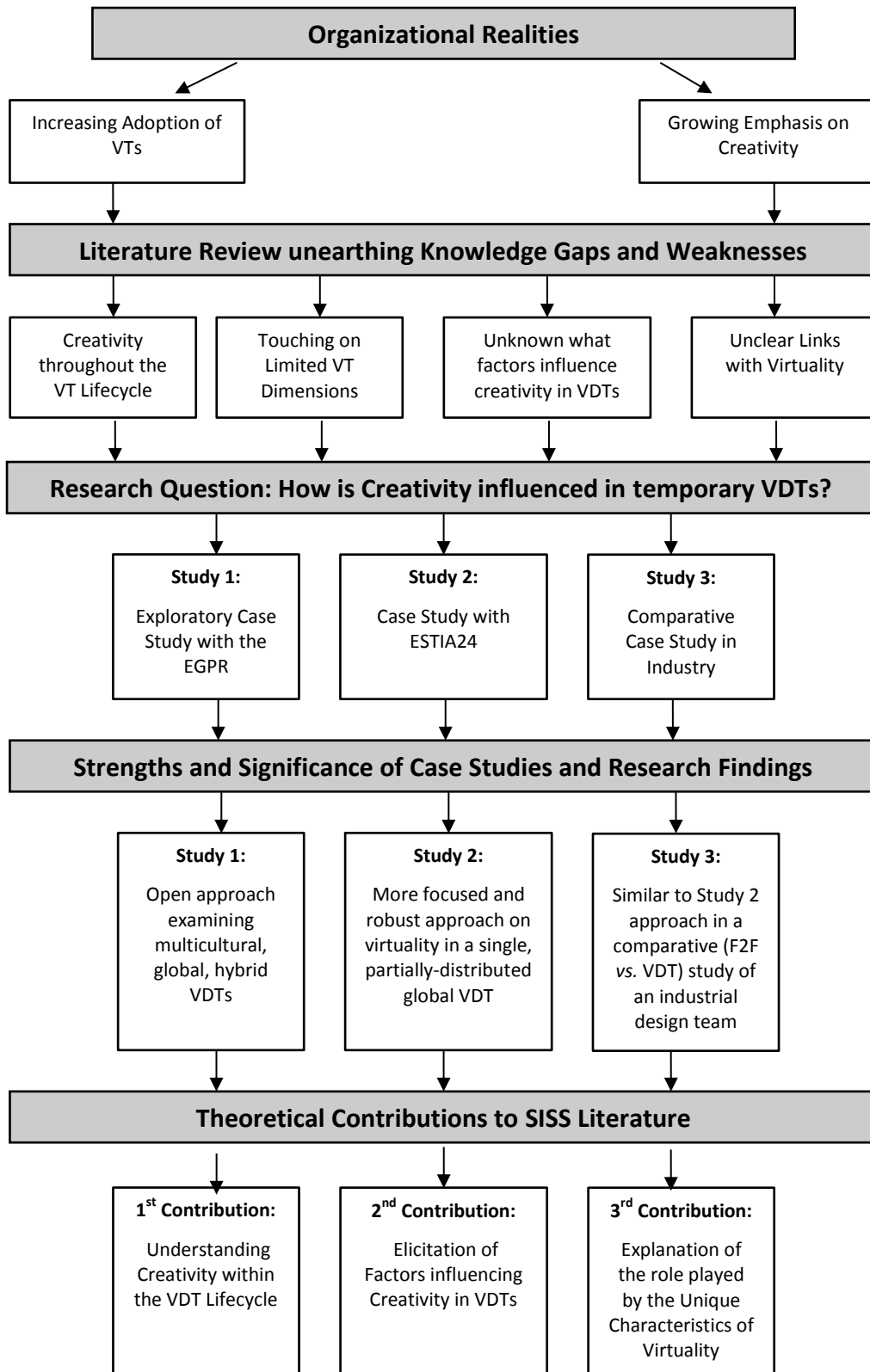


Figure 1: Research Organization Steps and Rationale

1.6 Structural Body of the Thesis

This thesis is divided into ten chapters. In **Chapter 1, Introduction**, I introduced the research topic; presented the research aim and question, empirical context and approach; and delineated the manner in which the research and thesis are organized.

In **Chapters 2 and 3, Literature Review**, I review the literature on VTs (Chapter 2) and creativity (Chapter 3). Both chapters summarize and critique extant knowledge and make reference to design, insofar as it has been discussed within each literature.

In **Chapter 4, Theoretical Framework**, I bring the literatures together and develop a theoretical framework--distilled from the cross-disciplinary review—which then leads to the development of the RQ and objectives that guided the thesis.

In **Chapter 5, Research Approach**, I present, and justify the selection of, my research approach. I describe more specifically the epistemology, ontology and methodology characterizing this thesis and juxtapose the selected stance, strategy, and methods onto others and explain their suitability for addressing the RQ.

Chapters 6, 7 and 8, Empirics, comprise an in-depth presentation of case studies. Each chapter contains a joined analysis and findings section.

In **Chapter 9, Discussion**, I present the VDT context characterizing the teams under study, and synthesize the findings from the three case studies across them within a discussion on the thesis' theoretical contributions.

In **Chapter 10, Conclusion**, I summarize the work presented in the thesis, and outline the thesis' limitations as well as its implications for research and practice.

Chapter 2: Virtual Team Literature

In this chapter, I present a literature review on Virtual Teams (VTs) by drawing on the Information Systems (IS), management, organizational and design literatures. The chapter begins with an attempt to conceptualize virtuality and understand what is unique and topical about it. It proceeds by situating VTs within the wider literature on virtuality, and then introduces and defines VTs and discerns different types. The VT process and lifecycle are subsequently discussed, while the chapter goes on to outline the benefits of VTs, their uses in industry, and their challenges as well as other issues that have received academic attention within the VT literature. Before closing, VTs are also discussed in the context of design, insofar as they have been researched.

2.1 Understanding and Conceptualizing Virtuality

Though relatively new (with its routes back in the 1990s), the literature on virtuality is extensive and embraces a number of topics. Common terms one comes across within this literature, such as the *virtual* or *virtuality*, have been used dissimilarly (Woolgar, 2002). According to certain scholars, both terms suggest that the virtual does not represent something real, but instead indicates the potentiality of a situation. As Sotto (1998) puts it, “... the term ‘virtual’ can be said to mean: not actually existing but as if actually existing. In this sense, a virtual artefact is an event or entity that is real in effect but not in fact” (p. 79). Recent literature discerns three constructs that are associated with virtual work: VTs, remote control, and simulations (Bailey *et al.*, 2012).

Virtuality has been viewed as an umbrella term that can be used to describe virtual memory, VTs, virtual organizations, virtual switching and virtual reality (Mowshowitz, 1997). Another interpretation is that virtuality is a construct that, through the use of Information and Communication Technologies (ICTs), and thus increased possibilities for connectivity and interactivity, extends the boundaries of a traditional organization. It is largely believed, for example, that—as opposed to a physical environment which is characterized by walls and other such boundaries of

physical character—a virtual environment is flexible, nonlinear and unbounded (Zigurs and Qureshi, 2001). As Schultze and Orlikowski (2001) put it, “...*virtual ways of organizing have been posited to be: dynamic; networked; outsourced; distributed; digital; flexible; collaborative; and emphasizing intellectual capital, innovation, knowledge, learning, and temporary contracts*” (p. 46). Following from these articulations of virtuality, virtual organizations have been defined as “... *electronically networked organizations that transcend conventional organizational boundaries*” (Burn and Barnett, 1999, p. 216). However, other scholars assert that virtuality is not simply about extending traditional boundaries (e.g. geographical) that have been found to be the case in physically collocated organizations, but is also seen as an emergent, and increasingly popular, form of work organization (Panteli and Chiasson, 2008; Panteli and Dibben, 2001).

Overall, there is an overarching recognition within this literature that—due to the continuous technological advances and the multiple facets of virtuality—the nature of virtuality continues to be only partially conceptualized and explored (Kreps, 2012; Panteli and Chiasson, 2008). Further, there is debate in current scholarship as to whether virtuality should be distinguished from reality or whether it should be seen as a digital space which individuals use to interact; for example, Schultze and Orlikowski (2001) coin the notion of the *reality of virtuality*, suggesting an alternative articulation of what we refer to as reality. Kreps (2012) has a different take on virtuality; by considering constructs from the field of philosophy—such as perception, consciousness and reality—he notes that *digital virtuality*, as he refers to it, extends the virtuality that is human consciousness; and though not material, digital virtuality crafts spaces which are real enough; thereby challenging contentions about virtuality being different to reality.

A question that nonetheless arises, and which I address next, is where are VTs positioned within this emerging literature.

2.2 Situating Virtual Teams within the Virtuality Literature

Situating VTs within the wider literature on virtuality is important because, as Hamrin and Persson (2010) claim, we have to put the ecosystem (VTs) in its habitat (virtuality context) in order to understand it better. I use Panteli's (2009) model which encompasses different discourses within this literature, categorized per three dimensions: user interactions (single- vs. multi-player); technology availability (limited vs. widespread); and relationship with organizations (within vs. beyond). She identifies four levels of virtuality research, which, though they do not represent stages of growth of virtuality, constitute distinct levels of virtuality research in their own right. They are: Computer-Mediated Communication (CMC), VTs and Organizations, Online Communities, and Virtual Social Networks (Figure 2).

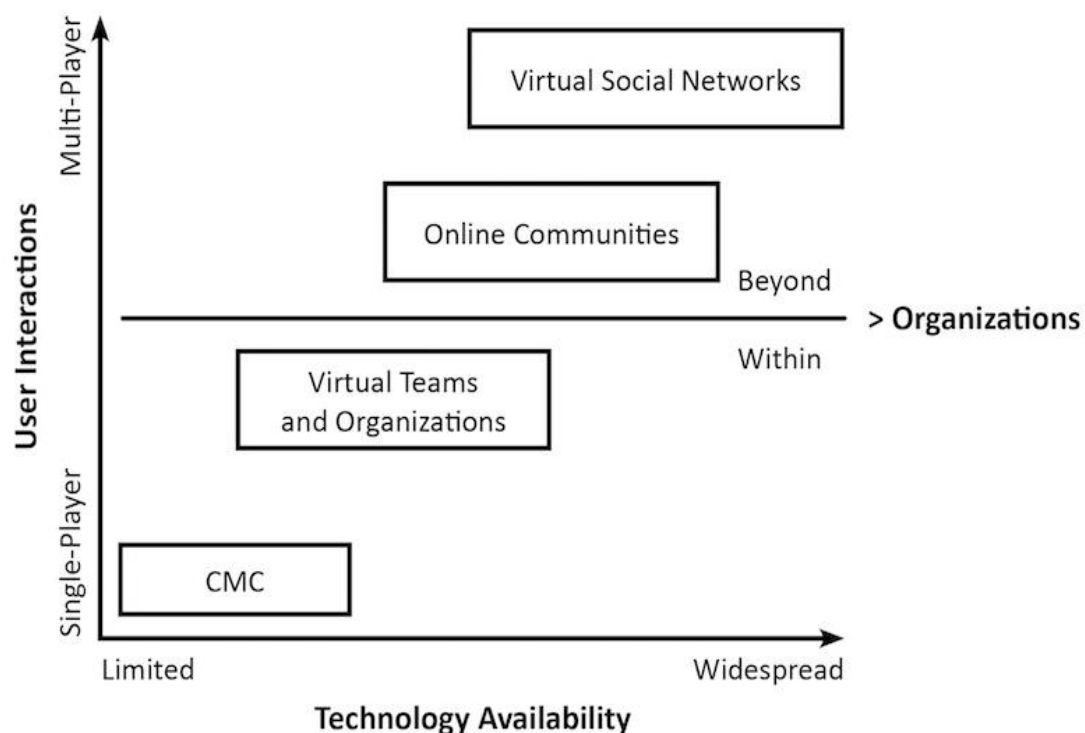


Figure 2: Levels of Virtuality Research (after Panteli, 2009, p. 2)

The first level centres on CMC—computerized, predominantly text-based, communication in social and organizational settings, and its impact on single players. For example, research on CMC describes the influence of ICTs on communication, highlighting the challenges brought about by the absence of nonverbal and paraverbal cues (Becker-Beck *et al.*, 2005); the implications of the use of Video-

Conferencing (VC) systems for business interactions (Panteli and Dawson, 2001); media choice theories (Palmer and Speier, 1998); and other such issues.

The second level is about virtual organizations and VTs, extending the former level by considering the collaborative character in addition to technology use in its own right. Issues surrounding this level represent the core of this chapter and are discussed systematically in the next sections. It is also important to state that the term *team* is used in this literature to mean “... *a collection of individuals who are interdependent in their tasks, who share responsibility for outcomes, who see themselves and are seen by others as an intact social entity embedded in one or more larger social systems, and who manage their relationship across organizational boundaries*” (Cohen and Bailey, 1997, p. 241). This definition stresses that *teams* are different to *groups*; a team is characterized by mutual accountability among members and collaborative effort toward an agreed delivery, as opposed to a group which is characterized by individual accountability and its purpose is likely to be the same as the organization’s mission (Katzenbach and Smith, 1993).

The last two levels in Panteli’s model concern multiplayer online communities and virtual social networks. Individuals become members of these communities based on common interests and get together online, rather than Face-to-Face (F2F), in a virtual environment. Rheingold (1993) sees these configurations as social aggregations with large populations and numbers of interactions within them, which can lead to long-lasting relationships. Virtual social networks are rapidly emerged massive multiplier communities, whose importance has increased, as they have become commonplace in today’s social interactions (Panteli, 2009). Scholarly interest on these levels revolves around Facebook (Ellison *et al.*, 2007; Light and McGrath, 2010) and their implications (e.g. privacy); health-related virtual communities, offering a platform of communication between patients (Eysenbach *et al.*, 2004); online games (Kolo and Baur, 2004); and the use of dating websites (Light, 2007).

Following the synopsis of the conceptualizations of virtuality and after positioning VTs within the wider virtuality literature, I proceed to a review of the VT literature.

2.3 Virtual Teams: Perspectives and Definitions

In Table 1 below, I provide some of the most popular definitions of VTs.

Table 1: Definitions of Virtual Teams

Definitions of Virtual Teams	Scholars
<i>"A VT is a group of people and sub-teams who interact through interdependent tasks guided by common purpose and work across links strengthened by information, communication, and transport technologies."</i>	(Gassmann and Zedtwitz, 2003, p. 244)
<i>"[A VT is] a group of people who interact through interdependent tasks guided by a common purpose [...] and] work across space, time, and organizational boundaries with links strengthened by webs of communication technologies."</i>	(Lipnack and Stamps, 1997, p. 6)
<i>"[VTs are] teams whose members use technology to varying degrees in working across locational, temporal, and relational boundaries to accomplish an interdependent task."</i>	(Martins <i>et al.</i> , 2004, p. 808)
<i>"Global Virtual Teams (GVTs) are groups that (a) are identified by their organization(s) and members as a team; (b) are responsible for making and/or implementing decisions important to the organization's global strategy; (c) use technology-supported communication substantially more than F2F communication; and (d) work and live in different countries."</i>	(Maznevski and Chudoba, 2000, p. 473)
<i>"VTs are groups of geographically and/or organizationally dispersed co-workers that are assembled using a combination of telecommunications and information technologies to accomplish an organizational task."</i>	(Townsend <i>et al.</i> , 1998, p. 18)

As the definitions in Table 1 reflect, the VT literature pertains mainly to the characteristics that describe VTs, predominantly computer mediation and geographical dispersion; and secondarily, cultural diversity, degree of distance, and temporal or organizational dispersion. Some, also, differentiate VTs from Global Virtual Teams (GVTs), arguing that the former are teams that function via CMC but their members are physically proximate (not collocated, but relatively close, e.g. in the same building or in the same country) and culturally similar; and the latter are teams whose members work from different countries and are culturally dissimilar (McDonough III *et al.*, 2001). These, and other, differences are discussed further in the following section. Commonly, it has been argued that VTs are characterized by a number of discontinuities—temporal, spatial, work group, organizational, relationship and cultural (Watson-Manheim *et al.*, 2002). VTs are also known for

their unique characteristics, or criteria for assessing their degree of virtuality that have been used. Though these seem to vary within the VT literature, Schweitzer and Duxbury (2010) outline the following as being the most salient ones: geographical dispersion, temporality, boundary spanning, cultural diversity, and enablement by communication technology.

The VT literature has been limiting in that it has centred on specific types of VTs and has unavoidably excluded other types (e.g. asynchronous vs. hybrid). For instance, student-based VTs have been fathomed, while completely asynchronous VTs have also been looked at extensively, though asynchronicity is not always the case in the industry. Adding to this is the limitation that the study of VTs is relatively young as a research topic in certain disciplines, including engineering design; a discipline wherein the deployment of VTs is becoming more common. Similarly, most researchers have conceptualized VTs as completely different from traditional, F2F, physically collocated teams and have therefore based their studies on comparisons between the former and the latter. This, again, presents a limitation, as teams that combine virtual and F2F functions to different degrees, thus teams that are more or less virtual, have been posited (Dixon and Panteli, 2010; Griffith *et al.*, 2003; Watson-Manheim *et al.*, 2002). Considering therefore that not all VTs are the same, the chapter continues with a discussion around their different types.

2.4 Typologies of Virtual Teams

Discerning the different types of VTs found in the literature is important because not all types of VTs are presented with the same opportunities and challenges. And different scholars have unpacked different types of VTs by looking into different dimensions of virtuality. There exist different configurations of VTs and this is also shown by the different names chosen to describe VTs: distributed, dispersed, global, cyber, computer-supported, intercultural, spatial, and partially distributed. There are various differences between the different types of VTs, including the media, or ICTs, used; their purpose; their degree of dispersion; and their level of continuity. It is generally acknowledged in the literature that VTs are first of all teams, thus collections of at least three participants (e.g. Köhler *et al.*, 2012), and their structure may vary in terms of complexity.

Though scholars in general are agreed on the premise that different types of VTs exist, they have used different ways to discern these different types. For instance, Cascio and Shurygailo (2003) use the number of locations along with the number of managers involved in a VT to identify different types. And they argue that different issues are likely to arise in the different types of VTs and different strategies are needed to be in place in order for these issues to be resolved. The VT types they identify are:

- Teleworkers (with one manager in one location);
- Remote team (with one manager of a distributed VT);
- Matrixed teleworkers (multiple managers in one location); and
- Matrixed remote teams (multiple managers across multiple locations).

Panteli (2004b) delineates in her model some of these differences (Figure 3) and argues that some are more or less diverse, global and temporary than others. For instance, per her model, VTs are either national (local) or international (global). Notably, a VT whose members speak the same language and are of the same origin do not face intense cultural differences as do GVTs. Dubé and Paré (2001), specifically, add that *“GVTs differ from more localized VTs in several respects. Indeed, GVT members are dispersed around the world and rarely meet F2F, if at all, during*

the course of a project. In addition, members represent different cultures and speak different languages, and GVTs face particular technological dilemmas around accessibility and compatibility” (p. 71).

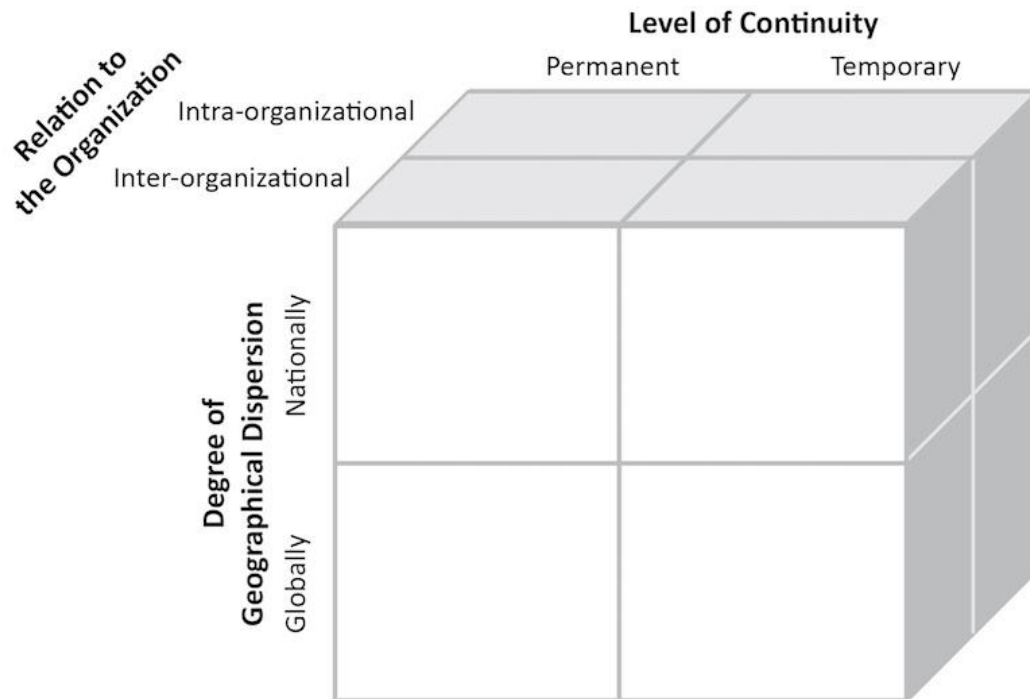


Figure 3: A Typology for Virtual Teams (after Panteli, 2004b, p. 28)

The level of continuity refers to the fact that some VTs may have been initiated for a very specific objective, upon completion of which they are disassembled, while other VTs might be permanent or polychronic, working on a series of different projects, one after the other. Members of temporary VTs often experience low degrees of familiarity with each other, influencing their performance levels (Bell and Kozlowski, 2002; Espinosa *et al.*, 2003). Further, this may influence trust levels and overall dynamics within a VT environment (Panteli, 2004b). Literature on trust in VTs, in particular, suggests that temporary VTs find it particularly challenging to develop trust due to their short lifecycle (Crisp and Jarvenpaa, 2013; Panteli and Duncan, 2004). According to the same model, VTs' relation to the organization might also vary and, accordingly, scholars speak of either inter- or intra-organizational VTs. Palmer and Speier (1998) pinpoint two types of such relationships: (a) VTs comprising individuals who, though from the same parent organization, belong to different functional areas and who can be housed in different locations (i.e.

members of the same organization); and (b) VTs whose members come from different parent organizations who belong in the same functional areas but use ICTs to interact (e.g. contractors). This outlook on virtual teaming arguably alters the boundaries that characterize traditional, F2F teams. Specifically, what have traditionally been seen as boundaries (location, inter-/intra-organizational)—or *“imaginary lines that mark the edge or limit of something”* (Espinosa *et al.*, 2003, p. 158)—have, in the virtual locale, been replaced with temporal, geographical, social, cultural, historical, technical, political (Orlikowski, 2002) geographical, functional, temporal, organizational, and identity boundaries (Espinosa *et al.*, 2003). And interestingly, boundaries within VTs have different consequences under different circumstances and different implications for different members (Watson-Manheim *et al.*, 2011).

Evidently, therefore, though there are ostensibly no geographical boundaries in virtual teamwork, research has shown that these, in essence, still seem to exist; but in different forms. Indeed, discontinuities caused by the emergence of these boundaries have been discussed in extant literature, highlighting, among others, the cross-boundary dimension of VTs (Watson-Manheim *et al.*, 2011). What, however, has also been shown is that despite the emergence and dynamic character of discontinuities in VTs, continuities may also emerge from them. For instance, Dixon and Panteli (2010) suggest that the inter-organizational dimension of VTs—as shown in Panteli’s (2004b) earlier—may give rise to a sense of identity and belonging among the members of an inter-organizational VT arrangement which may, to a high degree, detach itself from the organizations to whom its different members belong.

Nevertheless, though models such as the ones offered by Panteli (2004b) and Griffith *et al.* (2003) bring to light some key differentiators among different VTs, they are not inclusive of all different types of VTs encountered in research or industry. They ignore important differentiators, such as the types of ICTs used and the types of tasks undertaken. Moreover, depending on the ICTs available, virtual co-workers may have the option to choose among synchronous (e.g. telephone, VC) or asynchronous (e.g. email) media (Coleman, 1997), and they might even consider periodic F2F communication (Maznevski and Chudoba, 2000). Though less common,

synchronicity in the workplace has driven to the creation of synthetic worlds; settings wherein through the use of an *apparatus* that allows for a virtual three-dimensional workplace, co-workers from different locations are brought to very close proximity (Orlikowski, 2010). Though Panteli's (2004b) model neglects the aforementioned issues, these have been overcome. Griffith *et al.* (2003) developed a model (Figure 4) which evidently goes beyond the dichotomy between F2F and pure VTs and which shows that there exist hybrid teams, which combine both modes; the F2F and the virtual.

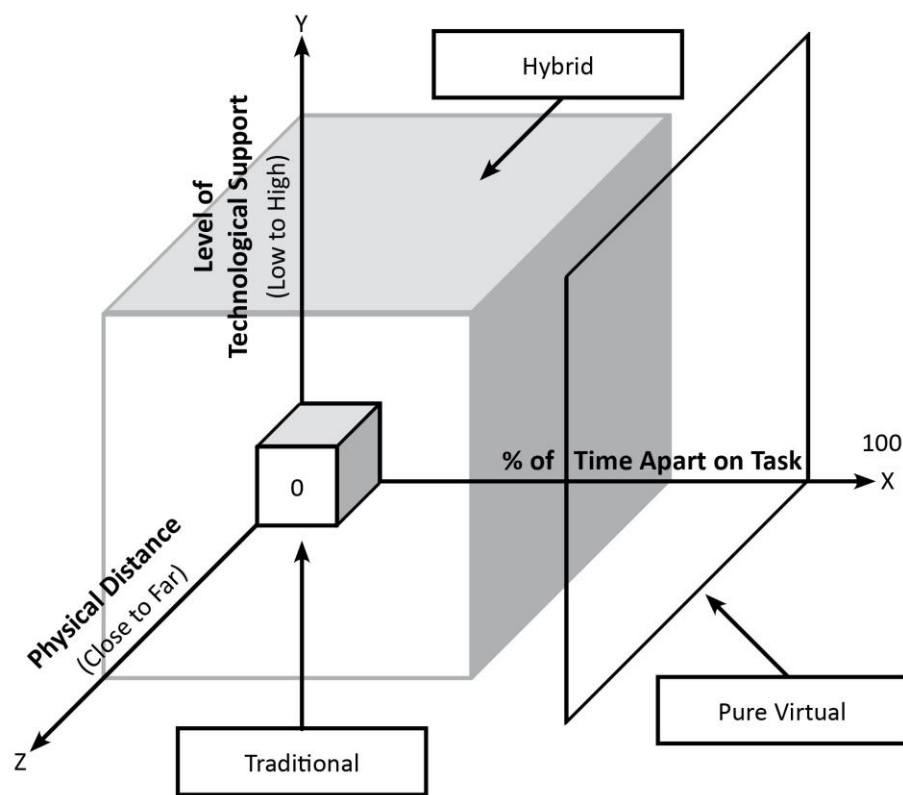


Figure 4: Dimensions of Virtualness (after Griffith *et al.*, 2003, p. 267)

Fiol and O'Connor (2005) build on this model and identify a number of characteristics for each of the three types (i.e. F2F teams, hybrid teams, and pure VTs). As they argue, (a) traditional, F2F teams are characterized by: low uncertainty, high visibility, high number of rich cues, low diversity, and high influence of politeness rituals; (b) hybrid teams (VTs with periodic F2F communication) are characterized by: moderate uncertainty and visibility, intermittent rich cues,

moderate diversity, and intermittent politeness cues; and (c) pure VTs are characterized by: high uncertainty, low visibility, fewer rich cues, high diversity, and fewer politeness rituals. A similar typology of VTs suggests that the degree of virtuality in teams can be characterized using three dimensions (time, member, distance): (a) time spent by the VT participants doing work separately; (b) the members that spent time doing work virtually; and (c) the degree of separation among the team members (Schweitzer and Duxbury, 2010). Another dimension that has been recently added is the degree of spontaneity of VTs (Tong *et al.*, 2013). According to this view, spontaneous VTs are teams that commonly emerge within organizations, based on individual employees' initiative, in order to address an issue that has arisen.

There are other VT configurations as well. For example, subgroups often emerge as a unique organizational configuration within VTs (O'Leary and Mortensen, 2010; Panteli and Davison, 2005). The psychology literature suggests that subgroups reveal a certain degree of heterogeneity within a team and they therefore represent collections of individuals within teams that share some common characteristics, such as occupation or gender (Park and Judd, 1990).

2.5 Virtual Team Process and Lifecycle

VT scholars have looked into the VT process (Powell *et al.*, 2004) and the VT lifecycle (Furst *et al.*, 2004; Hertel *et al.*, 2005). Process-based models of VTs (e.g. Figure 5) assume that the added variables of increased diversity and use of CMC, among others, challenge the process undergone by individuals when aiming to accomplish their task(s) (Powell *et al.*, 2004). The aforementioned scholars take an input-process-output outlook on the way the VTs operate and discuss the socio-emotional (relationship building, cohesion, trust) and task-related (communication, coordination, task-technology-structure fit) processes that characterize VTs, based on their review of the then (back in 2004) extant VT literature. In their study, Powell and her colleagues contributed a holistic framework encompassing the available knowledge—already known issues surrounding VTs (which I elaborate on in section 2.8 that follows)—in their effort to (a) assess the state-of-the-art in VT literature; and (b) guide future research.

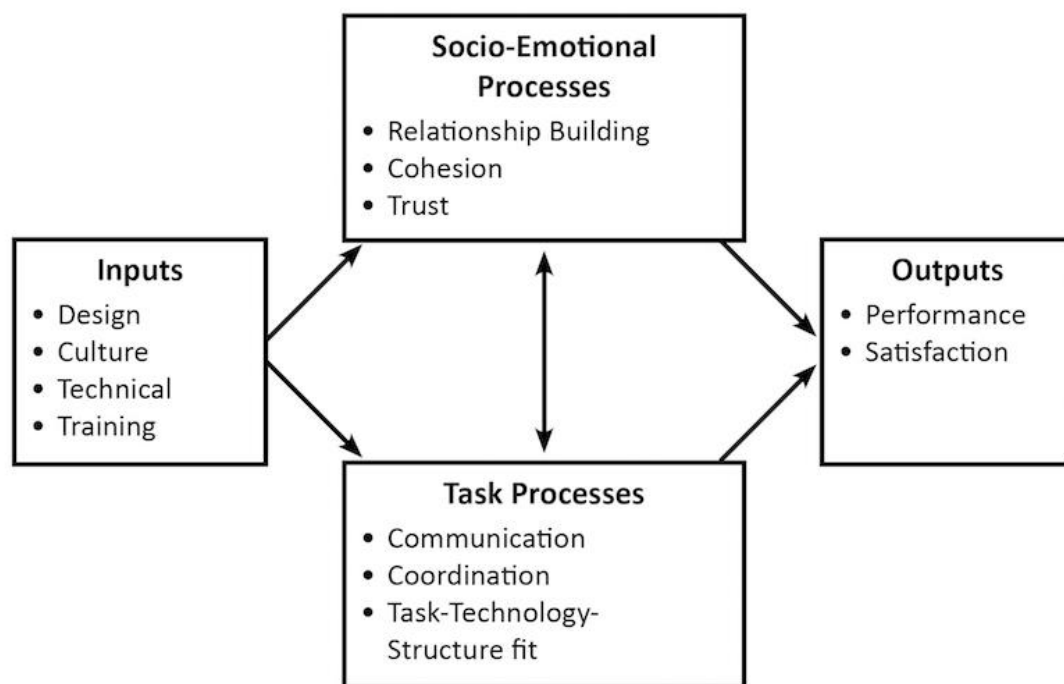


Figure 5: Virtual Team Process (after Powell *et al.*, 2004, p. 8)

Other scholars have looked into the VT lifecycle more explicitly. The studies focusing on the VT lifecycle differ from the aforementioned study on the VT process, as they contribute a chronological perspective of specific stages and sets of activities that

take place from start to end of a VT project. For example, Bell and Kozlowski (2002) argue that the VT lifecycle is one of the unique characteristics of VTs. They find, for example, that when a task is characterized by low levels of complexity, VTs are more distributed in time, have more permeable boundaries and shorter lifecycles, and their members perform multiple fluid roles. In contrast, when a task is high in complexity, then the VT operates simultaneously (or is characterized by low levels of temporal dispersion), its boundaries are less permeable and its lifecycle more continuous, while its members undertake singular roles. The forenamed scholars therefore show with their study that VT lifecycle is different to a traditional team's lifecycle, as it has implications not only for temporal dispersion, boundary permeability, task complexity, and member role undertaking, but also for effective leadership (which I will not be discussing here as they are outside the scope of this section).

Furst *et al.* (2004) agree that VTs' lifecycles are more challenging than traditional teams' lifecycles. In their longitudinal study of six VTs in the food delivery industry—which they investigate from start (inception) to end (delivery), thus covering the entire VT lifecycle with their approach—they borrow existing frameworks from previous studies to detail the factors that they find to influence VT performance in each of the different stages of the VT lifecycle. The first framework they consider of relevance to the VT lifecycle unearths four stages that the development process comprises: forming, storming, norming and performing (Tuckman, 1965). This framework, known as Tuckman's *Stage Model of Development*, suggests that during the forming stage of a team, members exchange information both directly (e.g. through discussions) and indirectly (e.g. through nonverbal cues). It is for this why Furst and her colleagues consider this model to be helpful in our understanding of the VT lifecycle, as such nonverbal cues may not be available when communication is attained via ICTs. The second framework they use, Gersick's *Punctuated Equilibrium Model*, focuses on the influence of a deadline on a team's development process. Per this model, a team's lifecycle comprises two phases, which are separated by a midpoint halfway through meeting the deadline (Gersick, 1994). As Furst *et al.* (2004) explain, “[during] Phase I, teams try to establish a working agenda and to

develop norms that guide early project efforts. These activities parallel Tuckman's forming, storming, and norming stages. At the project midpoint, a transition occurs as teams assess the norms and assumptions set during Phase 1. Teams dissatisfied with their progress may seek advice from an outside leader or facilitator in order to develop more effective norms. Teams satisfied with their performance maintain the status quo. With a successful transition, team members focus on their performance for the [second phase]" (p. 7). With these in mind, and with the four stages Tuckman suggests, Furst *et al.* (2004) develop their own framework recommending a number of interventions that VT managers can make to improve VT performance during each stage (Table 2).

Table 2: Interventions during the Virtual Team Lifecycle (Furst *et al.*, 2004, p. 15)

Forming	Storming	Norming	Performing
Realistic VT previews	F2F team building sessions	Create customized templates or team charters specifying task requirements	Ensure departmental and company culture supports VT work
Coaching from experienced team members	Training on conflict resolution	Set individual accountabilities, completion dates, and schedules	Provide sponsor support and resources for team to perform
Develop a shared understanding and sense of team identity	Encourage conflicting employees to work together to find common ground	Establish procedures for information sharing	
Develop a clear mission	Shuttle diplomacy and mediation to create compromise solutions	Distinguish task, social, and contextual information; design procedures appropriate for each	
Acquire senior manager support		Assign a team coach with skills for managing virtually	

As an example, it is found in their study that during the storming stage of the VT lifecycle it is important that the VT members meet in a F2F environment, despite the costs and inconvenience this might entail, in order to avoid any negative impact on performance at the later stages. It was similarly found that during the norming stage

VT members found it difficult to share information and remain committed; thus, the forenamed scholars encourage establishing procedures for information sharing as well as setting specific responsibilities for each VT participant.

Hertel *et al.* (2005) propose their own VT lifecycle model, a simplified version of which is depicted in Figure 6, which comprises five phases: preparations, launch, performance management, team development, and disbanding. Figure 6 details the activities undertaken by VT members during each phase of the VT lifecycle.

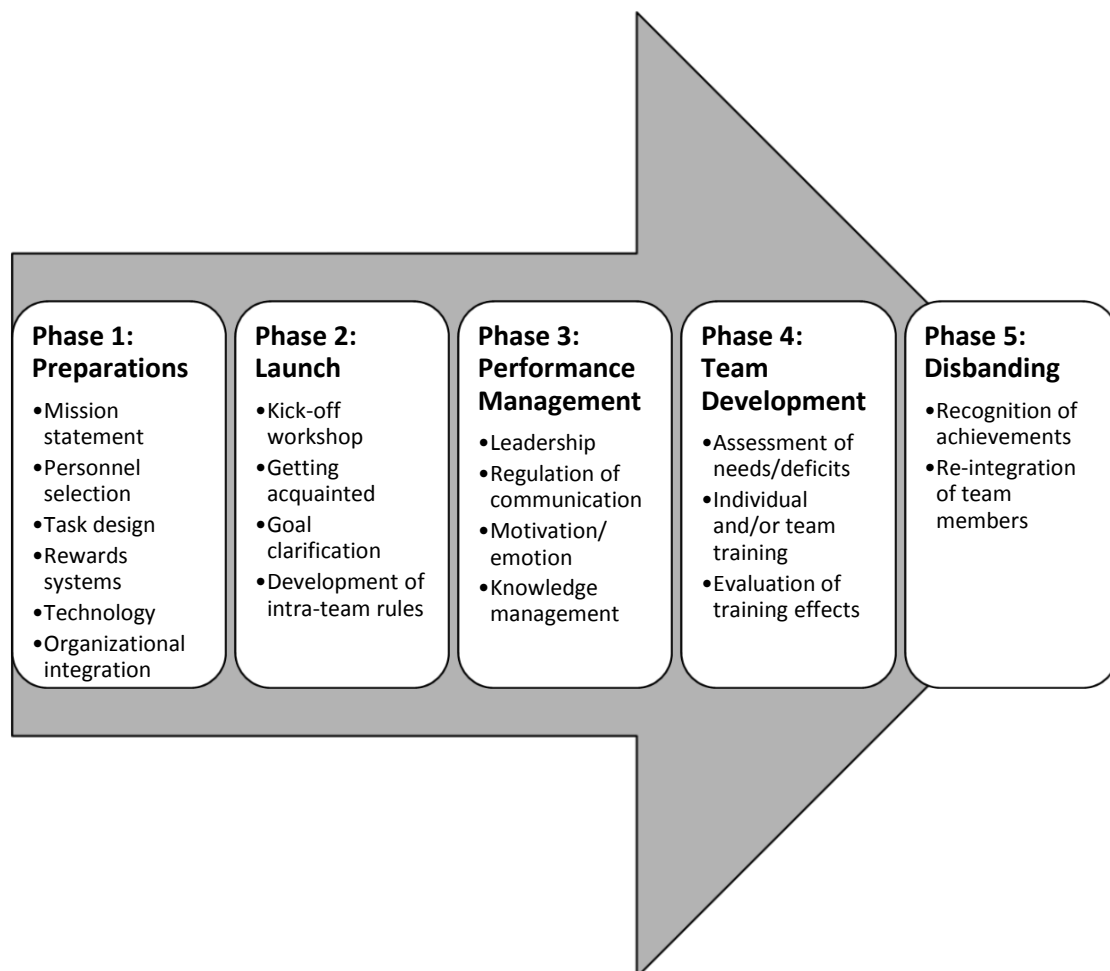


Figure 6: Virtual Team Lifecycle Phases and Activities (after Hertel *et al.*, 2005, p. 73)

Per this model, Phase 1, preparations, occurs when an organization is planning to commence a VT project. Activities here include task definition and personnel selection. Phase 2, launch, contains activities that take place during the kick-off of the VT project. The authors argue that in a VT environment, this phase is likely to be lengthier considering the VT members may be dispersed in a number of ways. Phase

3, performance management, is about spearheading and maintaining progress, motivation, and communication among the VT members. Phase 4, team development, entails processes that must be in place to ensure continuous development. Hertel *et al.* (2005) recognize that these two phases are characterized by their relationship with the issue of leadership. Phase 5, disbanding, includes activities that are related to final evaluations of, and reflection on, VT performance, as well as exploration for future collaborations. This VT lifecycle model, proposed by Hertel and his colleagues, is based on their review of the literature focusing organizational VTs with varying degrees of virtuality.

These studies examining the VT lifecycle contribute significant accounts of how and why the VT lifecycle is different to the lifecycle of traditional, F2F teams. For example, while Powell *et al.* (2004) use a simple input-process-output model to describe how the VT lifecycle can be seen as a process, Furst *et al.* (2004) and Hertel *et al.* (2005) go further to unpack distinct stages, either by drawing on previous theories from the psychology and management literatures (the former) or by considering existing VT literature (the latter). Either way, these studies demonstrate that the VT lifecycle is a challenging issue and VT managers and leaders should be ready to intervene pertinently and address the issues that may arise at different stages of the VT lifecycle.

Following this, I proceed to the next section, in which I outline some of the benefits of VTs.

2.6 Benefits of Virtual Teams

VTs have been viewed as a beneficial form of work organization in a number of sectors, including construction (Rezgui, 2007), and healthcare (Kimball and Eunice, 1999) among many others. Depending on the setting, virtual teaming may afford different types of opportunities. In education, for example, where “... *[it is as] if four people are working separately; together*” (Kitchen and McDougall, 1999, p. 252), collaborative learning has gained popularity because of the emergence of VTs (Smith, 2003). In healthcare, dispersed working, collaboration, and service delivery across regions have become watchwords, note Kimball and Eunice (1999), since “*relationships between people inside a hospital and those previously considered outside (customers, suppliers, managers of other services, community members) are becoming more important*” (p. 1).

In organizations, VTs offer unexampled opportunities to both the employer and the employee (Alavi and Yoo, 1997; Bell and Kozlowski, 2002; Townsend *et al.*, 1998). The employer, on the one hand, may access a wide reservoir of knowledge, spanning across geographical boundaries, capitalizing on international—and otherwise hard to reach—expertise, whilst also being given the option to develop international, inter-organizational consortia. Another enticement for companies is that producing deliverables across different geographical locations, work cycles and cultures (Gray and Igbaria, 1996; Palmer and Speier, 1998) may be achieved by simultaneously cutting down on travel expenses and reducing redundancies (Kayworth and Leidner, 2000). The employee, on the other hand, is provided with highly flexible working patterns, since technology enables them to work remotely from different locations, and makes it therefore easier for them to accommodate personal and professional issues, as well as to participate concurrently in multiple teams (Cascio, 2000). As Palmer and Speier (1998) state, “... *VTs overlay across the authority structure of the organization as members will have permanent physical homes as well as ‘psychological’ virtual homes*” (p. 3).

In Table 3 below I outline the benefits of VTs as per the literature review conducted by Ebrahim *et al.* (2009).

Table 3: Benefits of Virtual Teams (after Ebrahim *et al.*, 2009, p. 2657)

Benefits of Virtual Teams	Scholar(s)
Reducing relocation time and costs	(Rice <i>et al.</i> , 2007)
Able to digitally or electronically unite experts in highly specialized fields working at great distances from each other	(Rosen <i>et al.</i> , 2007)
Able to tap selectively into centre of excellence, using the best talent regardless of location	(Furst <i>et al.</i> , 2004)
Greater degree of freedom to individuals involved with the development project	(Prasad and Akhilesh, 2002)
Greater productivity, shorter development times	(McDonoughIII <i>et al.</i> , 2001)
Producing better outcomes and attract better employees, Generate the greatest competitive advantage from limited resources.	(Martins <i>et al.</i> , 2004)
Useful for projects that require cross-functional or cross boundary skilled inputs	(Lee-Kelley and Sankey, 2008)
Evolving organizations from production-oriented to service /information-oriented, Faster response times to tasks, Providing flexible hours for the employees, More sense of responsibility is more developed	(Precup <i>et al.</i> , 2006)
Provide organizations with unprecedented level of flexibility and responsiveness	(Powell <i>et al.</i> , 2004)
The extent of informal exchange of information is minimal (virtual teams tend to be more task oriented and exchange less socio emotional information	(Schmidt <i>et al.</i> , 2001)
Team communications and work reports are available online to facilitate swift responses to the demands of a global market. Employees can be assigned to multiple, concurrent teams; dynamic team membership allows people to move from one project to another. Employees can more easily accommodate both personal and professional lives	(Cascio, 2000)

In a similar vein, practitioners have conducted research into the benefits of VTs. For example, ChronosConsulting conducted a survey with 1764 North American (USA and Canada) companies employing 500+ staff and with annual sales of \$50M – \$5B+ in the financial services, oil & gas, telecom, cable, call center operations, consulting and transportation and found the following benefits of VTs that these companies

consider significant: productivity improvement, lower labour costs, expenses reduction, reduced travel expenses, wider talent pool, happier employees, reduced employee turnover, and hiring employees with flexible circumstances and/or disabilities (ChronosConsulting, 2011).

These benefits explain why centralized, vertical organizational forms in business have decayed, and instead prominent corporations with global presence, like the ones mentioned above, have begun to bank heavily on the virtual paradigm to accomplish their ulterior goals. Therefore, it is also important to show how organizations exploit these benefits offered by VTs. I illustrate this in the next section with the use of examples from industry.

2.7 Industrial Examples of Virtual Teams

Further to the above discussions on the different types of VTs and their benefits, it is important to discuss the industrial implications of VTs. The discussion that follows reveals mixed views on the adoption of VTs. On the one hand, employers and employees show excitement about partaking in VTs and posit a number of benefits, corroborating my discussion in the earlier section (2.6). On the other hand, however, organizations seem problematized with their use of VTs, due to some of the unique characteristics of virtuality.

Watkins (2013) demonstrates with this anonymous quote in his recent blog in the *Harvard Business Review Blog Network* what a real VT sounds like: *“I’ve run a [VT] for the past 18 months in the development and launch of [a website.] I am located in Toronto, Canada. The website was designed in Zagreb, Croatia. The software was developed in St. John’s, Newfoundland; Zagreb, Croatia; Delhi, India; and Los Angeles, USA. Most of the communication was via email with periodic discussions via Skype. I had one [F2F] meeting with the team lead for the technology development this past December”* (anonymous). Kopytoff (2012) reports the headquarters of Automattic—the firm behind WordPress—are usually empty as the company’s CEO, Toni Schneider, allows employees to work from home, with home being anywhere in the world, as long as they get the job done. Virtual teleworkers in the USA increased by 62% from 2005 to 2012 (McGlade, 2013).

These benefits are no news to companies. Prominent organizations in numerous industries (examples include Amazon.com, Hewlett-Packard, and Cisco Systems, Inc.) are early and committed adopters of VTs (Baralou and Shepherd, 2005). More than a decade ago, the *Wall Street Journal* reported the majority of companies employing more than 5,000 staff do employ VTs (de Lisser, 1999), major corporations in the high-tech industry, including Intel Corporation and Microsoft Corporation, have reported unprecedented success in using VTs (Townsend *et al.*, 1998); they have experienced success by, for example, revising and going over the idea of the—often unwieldy nowadays—far-flung management, and by developing cross-organizational VTs through strategic partnering and outsourcing. Research on the opportunities

afforded by VTs does not stop here, but it rather extends on several case studies. Boeing's *Virtual Office Programme*, for instance, pointed to measurable benefits, including increased productivity by ~ 22% rise in the quality of work, zero staff turnover, and contribution to the company's pollution credits (Wustemann, 1999). More recently, Intel Corporation pursued a study which showed that two-thirds of their staff are VT members (Nunamaker Jr *et al.*, 2009).

The anonymous quote from this blog sketches a clearer picture of some of the financial benefits for employers who are presented with the opportunity to employ staff from countries with lower labour costs: *"While salaries in Boston, New York and Silicon Valley skyrocket, salaries for programmers elsewhere remain much lower. Where I live, I regularly see positions advertised for \$35-40,000 for junior programmers. Expand outside the US and the price goes lower. I've hired awesome senior developers overseas for as low as \$18/hour"* (Lohrbeer, 2011). ChronosConsulting suggest that a company that they work with made cost savings of the value of 21% from the moment they employed VTs (ChronosConsulting, 2011).

Notwithstanding the phenomenal benefits of and the increasing impetus towards VTs, it has been acknowledged that prominent companies (e.g. IBM) have not had an easy road in adopting VTs (Ashkenas *et al.*, 2002); the main roadblock to this being that *"the rate of [technological] change exceeded [their] capability to respond"* (Ashkenas *et al.*, 2002, p. 6), or that ICTs outpace the companies' ability to somewhat revamp the processes associated with their teams. This takes us to the next section, where I detail the challenges and issues faced by VT managers and members.

2.8 Challenges of Virtual Teams

The VT literature has sought to examine issues and challenges that come with VTs. Earlier VT literature has stated that “[the] major disadvantages of VTs are the lack of physical interaction—with its associated verbal and nonverbal cues—and the synergies that often accompany F2F communication” (Cascio, 2000, p. 84). Another challenge presented to VTs is that ICTs develop quicker than do the culture and techniques of managing the virtual in organizations (Cascio, 2000; Duncan, 2009). There is generally consensus among VT scholars that hierarchical organizational structures and traditional and well-established management practices may not be appropriate in the virtual locale; this has propelled scholars from different disciplines to investigate some of the challenges faced by VT members and their organizations. Powell *et al.* (2004) argue that the challenges of VTs have to be addressed because VTs “... cannot be implemented on faith [or] represent an organizational panacea” (p. 20). It becomes apparent, therefore, that despite the enthusiasm about VTs in both research and practice, there is a remarkable void as to how virtuality influences certain organizational processes.

Bailey (2013) identifies, and develops a discussion around, the, as he calls them, ‘five killers of virtual working’: (a) lack of everyday non-verbal, F2F communication; (b) lack of social interaction; (c) lack of trust; (d) cultural clashes; and (e) loss of team spirit. Indeed, the extant VT literature has looked into these challenges facing VT members. Further challenges have been summarized as follows: reduced member awareness, reduced richness of information, miscommunication, new trust dynamics, greater conflict, cultural differences (Rice *et al.*, 2007), lack of physical interaction, loss of F2F synergies, lack of trust, greater concern with predictability and reliability, and lack of social interaction (Cascio, 2000). Further to the challenges emanating from the salient characteristics of VTs (e.g. geographical dispersion), there are latent characteristics too, e.g. the relative lack of opportunities for VT members to engage in social, or non-work-related work (Furst *et al.*, 2004).

In what follows, I present the main challenges found within the VT literature.

Trust

Indeed, building trust is a challenging task within VTs; and constitutes a large part of the VT literature. Early studies on this issue argue that a form of swift trust emerges in VTs environments, but this appears to be fragile and temporal in character (Jarvenpaa and Leidner, 1999). The notion of swift trust was originally developed by Meyerson *et al.* (1996) to describe a type of trust that occurs in short-term F2F teams, in which individuals/members have beliefs in others' reliability, dependability and capability. Developing swift trust is seen as a cognitive process that needs constant reinforcement and cultivation; otherwise it can easily break down, especially in a VT environment (Crisp and Jarvenpaa, 2013). Coppola *et al.* (2004) argue that though swift trust can develop in VTs, this has unique characteristics in comparison to swift trust in a F2F team environment. Based on this assumption, they also develop a number of strategies for VT members to maintain swift trust throughout the VT lifecycle: (a) establishing early communication; (b) developing positive social atmosphere; (c) reinforcing predictable communication patterns and actions that can benefit the VT; and (d) involving VT members in specific tasks.

Importantly, though trust in VTs is a topic that has been explored substantially in its own right, it has also been discussed in relationship with other issues that appear to be of importance within the VT literature. For instance, Panteli and Tucker (2009) explore the relationship between trust and power, arguing that power exertion may have significant implications for trust development within a VT; they find that, in a high-performing VTs in which trust is high, power shifts among those who are more knowledgeable in a specific domain within the VT lifecycle; in their own words, *"the power within their team as originating from knowledge and noted that at any given point in time the most powerful was the individual with the most relevant information"* (p. 114). In contrast, in VTs experiencing low levels of trust, power may be knowledge/information-unrelated and coercive (*Ibid.*).

Bierly III *et al.* (2009) explore the relationship between virtuality and trust in VTs and found that relationship conflict can have a detrimental effect on trust as it is commonly a difficult task to address interpersonal disputes in VTs characterized by high degrees of virtuality.

In a similar vein, trust has been found to influence VT durability; for long-term durability of VTs, F2F communication is critical, as, without it, the notions of commitment and interpersonal trust cannot be maintained successfully (Nandhakumar and Baskerville, 2006). Muethel *et al.* (2012) examine trust in new product development GVTs, with regards to three unique characteristics of virtuality: geographical dispersion, computer-mediation, and national, as they call it, diversity. Further to reinforcing the importance of trust in VTs, they conclude that trust has an enabling role for innovation. They also argue that trust matters the most when the three aforementioned characteristics are in play; in contrast, they find that trust was not influential in relation to other aspects of virtual teamwork, such as flexibility and team membership.

Leadership

Leadership constitutes another well-explored issue within the VT literature (e.g. Kayworth and Leidner, 2002). Within the context of VTs, leadership is usually referred to as *e-leadership* or *virtual leadership* and has been defined as “... a social influence process mediated [ICTs] to produce a change in attitudes, feelings, thinking, behaviour, and/or performance with individuals, groups and/or organizations [...] it may be associated with one individual or shared by several individuals as its locus changes over time” (Avolio et al., 2000, p. 617). Early on, scholars like Bell and Kozlowski (2002) offered models outlining the challenges a leader in a VT environment, or e-leader, as I will refer to it here, may encounter. They focus on four unique characteristics of virtuality—temporal distribution, boundary spanning, lifecycle, and member roles—and discuss how a successful e-leader should address each of them. For example, insofar as temporal distribution is concerned, “[effective] virtual team leaders are expected to be more likely to determine how to use [ICTs] to provide team members with necessary developmental experiences” (Bell and Kozlowski, 2002, p. 37). Zigurs (2003) argues that leadership in VTs represents an oxymoron. Owing to the unique characteristics of virtuality, an e-leader should be able to:

- *“Work together on an important business challenge that team members find personally compelling;*
- *Jointly define and commit to the team's identity, goals and processes;*
- *Implement a focused performance management process that is embedded in team routines;*
- *Create lavish information flow by using familiar as well as new communication technologies to overcome distance and time; and*
- *Tie these efforts together through the personal commitment and dedication of the team leader”* (Kerber and Buono, 2004, p. 9).

In addition, practices an e-leader should follow include: “(a) establish and maintain trust through the use of communication technology; (b) ensure that distributed diversity is understood and appreciated; (c) manage virtual work-life cycle

(meetings); (d) monitor team progress using technology; (e) enhance visibility of virtual members within the team and outside in the organization; and (f) enable individual members of the virtual team to benefit from the team” (Malhotra et al., 2007, p. 60).

It has also been asserted—e.g. in studies within the high-tech industry—that leadership in VTs takes different forms; it can be shared/collaborative throughout the VT lifecycle (Chamakiotis and Panteli, 2010; Davis and Eisenhardt, 2011; Neufeld *et al.*, 2010; O Toole *et al.*, 2002), based on the participants’ skills and areas of expertise in relation to the aims of each phase of the VT lifecycle. E-leadership can also be emergent, as e-leaders may emerge unexpectedly, which can influence a VT positively (Carte *et al.*, 2006). Yoo and Alavi (2004) find that emergent e-leaders enact three roles that differentiate them from other members: initiator, scheduler, and integrator. They also posit other behavioural differences, such as the fact that emergent e-leaders usually send longer and more frequent task-oriented emails in comparison with other VT members (*Ibid.*). Misiolek and Heckman (2005) unpack two patterns of emergent leadership in VTs; they are strong and weak, as they call them. The former concerned e-leaders who managed all aspects around the way in which the studied VTs functioned. The latter concerns leadership styles which did not allow the researchers to easily discern between leaders and non-leaders, thus leadership style being subtle.

E-Leadership is a topic of ongoing investigation within this literature. For example, other research has contributed accounts regarding personality traits and emergent e-leadership in VTs (Cogliser *et al.*, 2012), the relationship between trust and leadership (DeRosa *et al.*, 2004), and e-leadership dynamics (Ocker *et al.*, 2009a).

Conflict and Emotions

Recently, the issues of conflict and emotion in VT environments have attracted academic attention. Ayoko *et al.* (2011) discuss conflict-related emotionality in VT environments and identify what is it that triggers it; and they also suggest ways to manage conflict and regulate and reduce negative emotions. They find that VTs that engage in negative conflict typically perform unsatisfactorily and suggest a number of strategies that VT members could take on. For example, in the authors' own words, *"teaching VT members to appraise cognitive conflicts positively as sources of valuable information can help individuals to reappraise their initial reactions to disagreements"* (Ayoko *et al.*, 2011, p. 172).

On the other hand, Glikson and Erez (2013) speak about emotion displays in VTs and discuss how positive and negative emotions are manifested in VTs, focusing on the multicultural aspect of VTs. Their study is the first that posits and explores *"... emotion display norms in multicultural virtual teams, whereby shared expectations regarding expressions of emotion emerge among individuals who differ in their national identities"* (p. 29). Lastly, Baralou and McInnes (2013) argue that emotions in asynchronous, text-based VTs are associated with three intertwined aspects of the communication process between VT members; and discuss how these emotions are expressed through, and suppressed from, the asynchronous character of text-based interaction within a VT. Again, other studies that have focused on this area include the study of business strategic conflict in VTs (Lee and Panteli, 2010) as well as accounts regarding the relationship between conflict and performance in VTs (Kankanhalli *et al.*, 2007).

Presence

Presence is an interesting and enigmatic topic for VTs, as presence, traditionally, implies that individuals should be physically present. Interestingly, it has been argued that, in a VT, e-leaders have to manage “*what you cannot see*” (Helms and Raiszadeh, 2002, p. 240). Within the broader literature on virtuality, presence has been discussed in virtual communities, such as blogging (Panteli *et al.*, 2011); in studies comparing individual work and teamwork in virtual environments (Heldal *et al.*, 2007); and also specifically in the context of VTs (Panteli, 2004a).

It has been claimed that, in a virtual environment, presence is ambiguous, as an individual may consider his/her presence to be high in a particular situation, whereas another individual within the same VT may consider the same person’s presence to be low (Heldal *et al.*, 2007). Alternative articulations of presence have also been posited in virtual environments—one in which individuals are not physically present. Panteli (2004a) outlines the following three types of presence in VTs: present availability, absent unavailability, and silenced availability. For instance, in her study, present availability of VT members was evidenced both in terms of being online as well as in terms of time. Reversely, absent unavailability refers to the situation whereby “... *people who are temporarily unavailable to work on the team project and have to be absent from the shared-mediated environment due to commitments in their social (non-mediated) or personal-mediated environment*” (Panteli, 2004a, p. 69). As such, presence in a VT environment may be articulated differently to presence in a traditional environment, and understood best through other notions, such as that of availability.

Having discussed the main challenges faced by VTs, I proceed to other issues that have dominated this literature.

2.9 Technology and Virtual Teams

Given the dominant role of ICTs within VTs, scholars have sought to understand how ICTs are used for communication and collaboration purposes within a VT environment. With regard to the issue of the impact of medium use in VTs, Hans *et al.* (2011) show, in their comparative study, the differences between the VTs that used (a) F2F communication; (b) desktop audio-conferencing; (c) desktop VC; and (d) text only for their initial meetings. They conclude that medium selection for the first meeting of between VT members that are expected to work together did not have significant influence on the way in which the VT performed.

ICTs and media choice have also been seen as intertwined with VT effectiveness. Media richness theory suggests that different ICTs have different levels of richness, as per their capacity for feedback, number of cues, the communication channels used, and the degree of personalization they can afford, and sees F2F communication as the richest arrangement for communication (Daft and Lengel, 1986). However, other studies have shown that even media with low communication richness (i.e. lean media) are able to transmit cues that are not typically transferred in writing (Panteli, 2002). Overall, this theory fails to explain the effects of different ICTs on VT communication and collaboration (DeRosa *et al.*, 2004), while some studies have taken this further and have found that VC between members who are geographically dispersed begets critical thinking superior to that of teams that use VC locally (Alavi *et al.*, 1995). Additionally, the above theory has ignored the effects of different ICTs on team creativity; a theme which is of urgent managerial priority in today's innovation-driven economy (Amabile and Khaire, 2008). And interestingly, Smith and Blanck (2002) provide suggestions on which ICT is best for each task, based on two dimensions: (a) the degree of synchronicity of the medium (synchronous vs. asynchronous); and (b) the purpose of the message that is being exchanged (socially- vs. information-oriented) (Figure 7). Their findings suggest that pertinent technologies have to be selected for either communication of social character or project-related tasks. For example, they find that synchronous ICTs promote a friendlier spirit between two individuals within a VT and a higher degree of familiarity, leading to higher levels of trust as well.

	Synchronous ICTs	Asynchronous ICTs
Socially-oriented Messages	<ul style="list-style-type: none"> • F2F • Phone & Audio • VC 	<ul style="list-style-type: none"> • Voicemail • Electronic Bullet Boards & Fora
Information-oriented Messages	<ul style="list-style-type: none"> • Electronic Meeting Systems • Virtual Whiteboards • Data Conferencing 	<ul style="list-style-type: none"> • Internet/Intranets • Email • Group Calendars • Non-real-time Databases

Figure 7: ICTs per Synchronicity and Purpose (after Smith and Blanck, 2002, p. 299)

In the last two sections I have sought to discuss literature on the main challenges faced by VT members and on the issue of technology and media choice within VTs. In Table 4 that follows, I present a synopsis of both issues and challenges that have dominated the extant literature on VTs and provide example articles.

Table 4: Focus of the Virtual Team Literature

Issues and Challenges	Example Articles	Scholar(s)
Management, Descriptive Studies and Literature Reviews	Nature of virtual teams: A summary of their advantages and disadvantages Mastering virtual teams: Strategies, tools and techniques that succeed Surviving the paradoxes of virtual teamwork Virtual teams: A literature review Supporting teams in virtual organizations Virtual team research: An analysis of theory use and a framework for theory appropriation Real Strategies for virtual organizing	(Bergiel et al., 2008) (Duarte and Snyder, 1999) (Dubé and Robey, 2008) (Ebrahim et al., 2009) (Hawryszkiewicz, 1999) (Schiller and Mandviwalla, 2007) (Venkatraman and Henderson, 1998)
Trust	Building trust in virtual teams Swift trust in global virtual teams Trust is in the eye of the beholder: A vignette study of postevent behavioral controls' Effects on individual trust in virtual teams Communication and trust in global virtual teams Is anybody out there? Antecedents of trust in global virtual teams Global offshoring of engineering project teams: trust asymmetries across cultural borders Situating trust within virtual teams Trust and conflict within virtual inter-organizational alliances: a framework facilitating knowledge sharing Comparing traditional and virtual group forms: identity, communication and trust in naturally occurring project teams	(Coppola <i>et al.</i> , 2004) (Crisp and Jarvenpaa, 2013) (Dennis <i>et al.</i> , 2011) (Jarvenpaa and Leidner, 1999) (Jarvenpaa <i>et al.</i> , 1998) (Jarvenpaa and Keating, 2012) (Panteli, 2004b) (Panteli and Sockalingam, 2005) (Webster and Wong, 2008)
Leadership	E-leadership: implications for theory, research and practice E-leadership and virtual teams E-leadership styles for global virtual teams	(Avolio <i>et al.</i> , 2000) (Cascio and Shurygailo, 2003) (Chamakiotis and Panteli, 2010)

	<p>Boundary spanning leadership: Six practices for solving problems, driving innovation, and transforming organizations</p> <p>Leadership effectiveness in global virtual teams</p> <p>Leadership challenges in global virtual teams</p> <p>Leading virtual teams</p> <p>Bridging the gap between traditional leadership theories and virtual team leadership</p> <p>Leadership in virtual teams: Oxymoron or opportunity</p>	<p>(Ernst and Chrobot-Mason, 2010)</p> <p>(Kayworth and Leidner, 2002)</p> <p>(Kerber and Buono, 2004)</p> <p>(Malhotra <i>et al.</i>, 2007)</p> <p>(Zhang and Fjermestad, 2006)</p> <p>(Zigurs, 2003)</p>
Technology and Media Choice	<p>Principles of regulating interaction in teams practising face-to-face communication versus teams practising computer-mediated communication</p> <p>Technology alignment: A new area in virtual team research</p> <p>Supporting the work of global virtual teams: The role of technology-use mediation</p> <p>Testing media richness theory in the new media: The effects of cues, feedback and task equivocality</p> <p>Managing communication within virtual intercultural teams</p> <p>Does medium matter? A comparison of initial meeting modes for virtual teams</p> <p>Teams: virtualness and media choice</p> <p>Virtual team meetings: Reflections on a class exercise exploring technology choice</p> <p>Team leaders' technology choice in virtual teams</p> <p>The effects of cognitive style and media richness on commitment to telework and virtual teams</p>	<p>(Becker-Beck <i>et al.</i>, 2005)</p> <p>(Bjørn and Ngwenyama, 2010)</p> <p>(Clear, 2008)</p> <p>(Dennis and Kinney, 1998)</p> <p>(Grosse, 2002)</p> <p>(Han <i>et al.</i>, 2011)</p> <p>(Palmer and Speier, 1998)</p> <p>(Schaefer and Erskine, 2012)</p> <p>(Sivunen and Valo, 2006)</p> <p>(Workman <i>et al.</i>, 2003)</p>
Cultural Diversity	<p>Exploring the notion of 'cultural fit' in global virtual collaborations</p> <p>Managing communication within virtual intercultural teams</p> <p>Managing participative diversity in virtual teams: Requirements for collaborative technology support</p> <p>Exploring the Links Between Cultural Diversity, the Collaborative Conflict Management Style, and Performance of global virtual teams</p> <p>Major challenges in multi-cultural virtual teams</p> <p>A culturally-attuned distributed decision making model of global virtual teams in world summit on the information society</p>	<p>Cultural fit (Clear, 2010)</p> <p>(Grosse, 2002)</p> <p>(Qureshi <i>et al.</i>, 2000)</p> <p>(Samarah <i>et al.</i>, 2002)</p> <p>(Vinaja, 2003)</p> <p>(Zakaria and Cogburn, 2011)</p>

<p>Performance, Effectiveness and Success Factors</p>	<p>Virtual team performance in a highly competitive environment</p> <p>Team dispersion, information technology, and project performance</p> <p>Enhancing effectiveness on virtual teams: Understanding why traditional team skills are insufficient</p> <p>Not all group exchange structures are created equal: Effects of forms and levels of exchange on work outcomes in virtual teams</p> <p>Exploring the association between temporal dispersion and virtual team performance</p> <p>Virtual teams: Effects of technological mediation on team performance</p> <p>An examination of deception in virtual teams: Effects of deception on task performance, mutuality, and trust</p> <p>Exploring the notion of space in virtual collaborations: findings prerequisites for success in virtual teams</p> <p>Global virtual teams for value creation and project success: A case study</p> <p>Communication effectiveness in global virtual teams: A case study of software outsourcing industry in China</p> <p>Managing global design teams</p> <p>Virtual teams and creative performance</p> <p>Conflict and performance in global virtual teams</p> <p>The virtual team: Strategies to optimize performance</p> <p>The impact of team empowerment on virtual team performance: The moderating role of face-to-face interaction</p> <p>Global virtual teams: What impacts their design and performance?</p> <p>Something(s) old and something(s) new: Modelling drivers of global virtual team effectiveness</p> <p>The proximal virtual team continuum: A study of performance</p>	<p>(Algesheimer <i>et al.</i>, 2011)</p> <p>(Bardhan <i>et al.</i>, 2012)</p> <p>(Berry, 2011)</p> <p>(Cogliser <i>et al.</i>, 2013)</p> <p>(Colazo, 2010)</p> <p>(Driskell <i>et al.</i>, 2003)</p> <p>(Fuller <i>et al.</i>, 2012)</p> <p>(Hamrin and Persson, 2010)</p> <p>(Lee-Kelley and Sankey, 2008)</p> <p>(Martins <i>et al.</i>, 2009)</p> <p>(Min <i>et al.</i>, 2010)</p> <p>(Monalisa <i>et al.</i>, 2008)</p> <p>(Kankanhalli <i>et al.</i>, 2007)</p> <p>(Kimball and Eunice, 1999)</p> <p>(Kirkman <i>et al.</i>, 2004)</p> <p>(Prasad and Akhilesh, 2002)</p> <p>(Maynard <i>et al.</i>, 2012)</p> <p>(Workman, 2007)</p>
<p>Conflict</p>	<p>Conflict and performance in global virtual teams</p> <p>Trust and conflict within virtual inter-organizational alliances: a framework facilitating knowledge sharing</p>	<p>(Kankanhalli <i>et al.</i>, 2007)</p> <p>(Panteli and Sockalingam, 2005)</p>

	Exploring the links between cultural diversity, the collaborative conflict management style, and performance of global virtual teams	(Samarah <i>et al.</i> , 2002)
Emotions, Belonging and Identity	<p>Online work: Managing conflict and emotions for performance in virtual teams</p> <p>Emotions and the spatialisation of social relations in text-based computer-mediated communication</p> <p>Emotion display norms in virtual teams</p> <p>Team Identity Formation in virtual teams</p> <p>Comparing traditional and virtual group forms: identity, communication and trust in naturally occurring project teams</p>	<p>(Ayoko <i>et al.</i>, 2011)</p> <p>(Baralou and McInnes, 2013)</p> <p>(Glikson and Erez, 2013)</p> <p>(Mansour-Cole, 2001)</p> <p>(Webster and Wong, 2008)</p>
Knowledge Sharing and Management	<p>A Framework to analyze knowledge work in distributed teams</p> <p>The mutual knowledge problem and its consequences for dispersed collaboration</p> <p>Virtualness and knowledge in teams: Managing the love triangle of organizations, individuals, and information technology</p> <p>Use of collaborative technologies and knowledge sharing in co-located and distributed teams:</p> <p>Towards the 24-h knowledge factory</p> <p>Knowledge management and virtual organizations</p> <p>Knowledge management in virtual enterprises: A systemic multi-methodology towards the strategic use of information</p> <p>Working together apart? Building a knowledge sharing culture for global virtual teams</p>	<p>(Bosch-Sijtsema <i>et al.</i>, 2011)</p> <p>(Cramton, 2001)</p> <p>(Griffith <i>et al.</i>, 2003)</p> <p>(Gupta <i>et al.</i>, 2009)</p> <p>(Malhotra, 2000)</p> <p>(Pollalis and Dimitriou, 2008)</p> <p>(Zakaria <i>et al.</i>, 2004)</p>
Recent and Emerging Issues	<p>An examination of deception in virtual teams: Effects of deception on task performance, mutuality, and trust</p> <p>Go (con) figure: Subgroups, imbalance and isolates in geographically dispersed teams</p> <p>The role of subgroups in the communication patterns of global virtual teams</p> <p>Spontaneous virtual teams: Improving organizational performance through information and communication technology</p>	<p>(Fuller <i>et al.</i>, 2012)</p> <p>(O'Leary and Mortensen, 2010)</p> <p>(Panteli and Davison, 2005)</p> <p>(Tong <i>et al.</i>, 2013)</p>

2.10 Virtual Teams in Engineering Design: Virtual Design Teams

Engineering design is a collaborative activity accomplished in team environments (Ibrahim, 2012). More specifically, teamwork in design is important because “*groups of individuals [are called to] work together in order to accomplish problems they cannot solve on their own*” (Stempfle and Badke-Schaub, 2002, p. 477). VTs in the engineering design domain are commonplace, yet have received surprisingly limited scholarly attention. In this thesis, I use the term Virtual Design Team (VDT) to refer to VTs performing a design task.

Over the years, design teams have begun to use ICTs extensively at all stages of the design process, and therefore, some studies have been conducted examining design in Computer-Supported Collaborative Work (CSCW) environments. Though it was at first considered inconvenient—and perhaps unfeasible—to use computers during the conceptual design phase, when a product is still at its first stages, the global character of design teams has rendered it necessary to do so, because design team members are often dispersed across different locations and have no other means than to interact via ICTs (Wang *et al.*, 2002). There has traditionally been agreement in the literature that CSCW is increasingly the case in design. For instance, Abarbanel *et al.* (1996) discuss the example of Boeing engineers who view themselves as collaborators that use CSCW to accomplish their tasks.

There are significant findings in this literature focusing on design and CSCW. For instance, Tang *et al.* (2010), in their comparative study between a computer-mediated and a F2F design work environment, find that no significant aspects of the design process were altered in the computer-mediated environment. Specifically, the design process unfolded at the same speed and any design issues and transitional activities were similar in the two environments. While computer mediation was found to have some influence on the low-level cognitive activities, such as structural issues, no influence was observed on the high-level cognitive activities, such as behavioural and functional issues. However, this literature is limiting as it only concerns comparisons of specific design activities (i.e. sketching) and by no means looks into the implications raised by VDTs.

Design literature focusing on VDTs is surprisingly scarce. For example, Monalisa *et al.* (2008) coin the term *global design team* to refer to “a team in which members work for the same company on a specific design function and are geographically dispersed, culturally diverse, and share responsibility for producing deliverables within time and resource constraints” (p. 49). The forenamed authors conducted a study of eight VDTs in the high-tech industry with the aim of unpacking issues and problems that are often encountered in such teams. Through data generated from interviews and questionnaires with managers of the eight VDTs investigated, they infer that, though assembled to overcome design problems and be creative and effective, these teams often fail to achieve their goals, owing to technological, organizational and/or personal reasons. Thus, it follows that though no significant differences in design were found in CSCW design environments (Tang *et al.*, 2010), this is not the case in VDTs.

In addition, Monalisa *et al.* (2008) outline a number of challenges encountered in the teams they investigated: trust, communication, cultural difference, and time zone difference. As an example, it is argued in this study that the passivity characterizing team participation among Asian cultures influenced the effectiveness of certain design projects negatively, as Asian participants refrained from bringing up bad news to the rest of the VDT, or letting them know if there were delays in delivery. However, the above are not unknown challenges in conventional collaborative design. For instance, Fischer (2004) unpacks spatial, temporal, conceptual, and technological barriers in design teamwork. He argues that, though it may be challenging, these can be turned from barriers to opportunities, by, for example, cultivating an optimistic socio-technical working environment using CSCW that can foster the participants’ creativity.

Furthermore, Iorio *et al.* (2011) offer accounts from a study that comprised seven global VDTs composed of student designers who completed a design task for the duration of a semester using a popular, multipurpose virtual platform to collaborate, Second Life. Their study is based on the assumption that selection of pertinent tools is critical for any design activity and they therefore seek to unpack factors influencing the usage of certain collaborative tools in a VDT environment. These

factors are: tool simplicity, tool's ability to support team cohesion, the emergent need(s) for the tool, local factors relating to previous experiences of the members. They add that, in a VDT environment, pertinent ICT selection “... *is a complex interplay between the developers' expectations for tool use and emergent practices based on the functional needs of the network*” (p. 224). They also use the example of a desktop sharing tool which, though anticipated to be used extensively, was not adopted by the VDTs, revealing that the lack of customizability in a virtual environment (though this is Second Life-specific) may hinder a tool's successful use.

What is more, it has been asserted that the diversity emanating from bringing individuals from different contexts together via CSCW can be either deleterious for a team (Thatcher and Brown, 2010), or it can help the team deliver high levels of creativity (McDonoughIII *et al.*, 2001). Elias *et al.* (2011) hypothesize in their model, from a cross-disciplinary literature review study they conducted, that high diversity of designers encountered in a VDT can potentially lead to lower commonality of ideas (Figure 8).

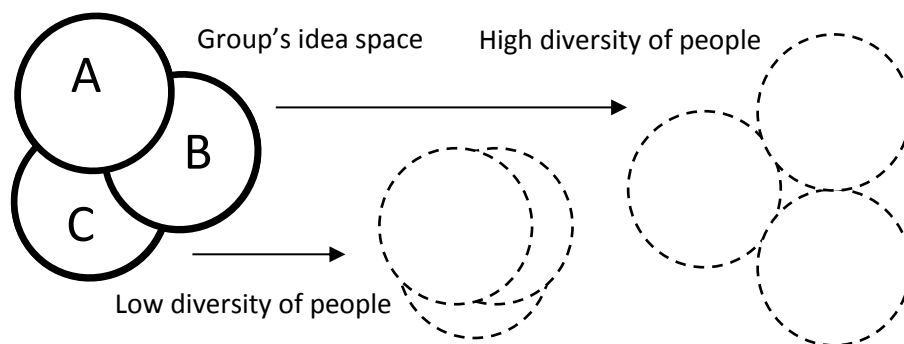


Figure 8: Team Diversity and Commonality of Ideas (after Elias *et al.*, 2011, p. 626)

It follows that though VDTs constitute an under-researched topic within the design literature, there still exist studies which demonstrate that findings from design literature focusing on CSCW in design may not be necessarily significant for VDTs.

2.11 Summary of the Virtual Team Literature

VTs—with their various configurations based on their length, purpose, degree of virtuality discontinuities, and on the geo-temporal and other dimensions discussed earlier in this chapter—are not an infrequent phenomenon; they have been rising in popularity among organizations and are of cross-domain significance, as we witness them in a number of different contexts (e.g. industrial, educational) and industries/domains (e.g. high-tech, advertising). Yet, research into VTs is not conclusive, and creativity features as an under-researched topic within this literature. This is because VTs constitute an emerging, continuously evolving phenomenon whose uses, benefits and challenges are constantly changing, as ICTs advance and as their usefulness and popularity increase. This literature posits and describes different types of VTs, and shows that their lifecycle differs from traditional teams' lifecycles. Further to some inherent and salient characteristics of VTs (e.g. dispersion), the literature also hints at a number of issues which have been seen as associated with their performance (e.g. trust). I refer to both their salient characteristics and other issues that have dominated this literature as unique characteristics of virtuality with the expectation of examining their influence on creativity in the following chapters.

Following the literature review on VTs, the next chapter presents a literature review on creativity.

Chapter 3: Creativity Literature

In this chapter, I present a literature review on creativity. I begin by introducing the topic, giving insights on its etymology, definitions and overall significance as a research topic. I continue by presenting different types and frameworks and discuss key creativity literature based on the individual-team-organizational framework. Also discussed is creativity in the engineering design context. Overall, I take a focus on specific concepts from this literature in order to pursue an understanding of creativity in the context of Virtual Teams (VTs). The chapter closes with a reflection on the reviewed creativity literature.

3.1 Creativity Literature: Etymology and Definitions

The word and concept of *demiurge* derives from the Greek *δημιουργός* (*demiourgos*), or else public worker (etymology: *δήμος* (*demos*) + *έργο* (*ergon*) or labour), and, though it was first associated with the creator of the universe (in Plato's *Timaeus*), it has also been treated as synonymous to a *craftsman* or an *artisan*. An outgrowth of *demiurge* is *δημιουργικότητα* (*demiourgikotita*)—the ability to create something new and the equivalent of creativity in ancient and Modern Greek. The term *creativity* itself finds its routes in Latin and, similarly to *demiurge*, it originally meant the *ex nihilo* act of God—thus creation from nothing—while with the passage of the years its meaning progressed, as I further explain below.

By reviewing the history and etymology of these terms, one comes to the realization that while the Greek origin highlights the association between labour and its usefulness, thus implying that something creative is to be of value to the public, the Latin—prevalent in several European languages today—underlines the absence of precedent to something creative. This, however, is not always relevant in practice, as, for instance, several resources and methods are nowadays in place for the sake of promoting one's creativity. Nonetheless, the concept of creativity has evolved considerably and has been discussed in a variety of different research domains and, as therefore, the term has been given different definitions and has been seen from different angles and in different contexts. Researchers that have investigated

creativity come primarily from the following disciplines: management, marketing, organizational studies, economic science, psychology, cognitive science, philosophy, engineering (industrial, software and architecture), education, the arts, music, theology, biology, linguistics, and sociology. In Table 5 below are some of the definitions found in the different discourses.

Table 5: Definitions of Creativity

Discipline	Definitions of Creativity	Scholar(s)
Management	<i>"the production of novel and useful ideas"</i>	(Amabile, 1988, p. 1)
Design	<i>"the ability to develop new problem descriptions to enable new solutions"</i>	(Akin, 1994, p. 9)
Human-computer Interaction	<i>"Creativity is the generation of ideas, which are a combination of two or more matrices of thought, which are considered unusual or new to the mind in which they arose and are appropriate to the characteristics of a desired solution defined during the problem definition and preparation stages of the creative process"</i>	(Warr and O'Neill, 2005, p. 122)
Psychology	<i>"the ability to produce work that is both novel and appropriate"</i>	(Sternberg, 1999, p. 3)

Providing however definitions for creativity is by no means exhausted here; it can be an endless process, as more than 1,000 definitions can be found in the different works (Aleinikov, 1999). Therefore, while my aim in citing the afore-presented definitions has been to consider different views of creativity from some of the disciplines that are related to this thesis, it becomes apparent that common denominator of these definitions is that they treat creativity as a process (generation/production) or as an ability. Sternberg and O'Hara (1999), for example, elaborate on the latter view of creativity and argue that it is interconnected with three abilities: to be synthetic, analytical, and practical. In this thesis, I adopt the definition of creativity as idea generation, *"with an end to itself"* (Amabile, 1988, p. 1), as she puts it. This definition agrees with the view that creativity forms part of the innovation process; more specifically, the notion of innovation comprises the following two stages: (a) the generation of ideas or creativity; and (b) the

implementation stage of the generated ideas (George, 2007; Somech and Drach-Zahavy, 2013) which can translate into innovative products, processes, and services through commercialization (Figure 9) (Andriopoulos and Dawson, 2009; Bessant and Tidd, 2007; Von Stamm, 2003). This, once again, highlights the distinction between creativity and innovation and contributes to the justification of the fact that the literature on innovation is not reviewed in this thesis.

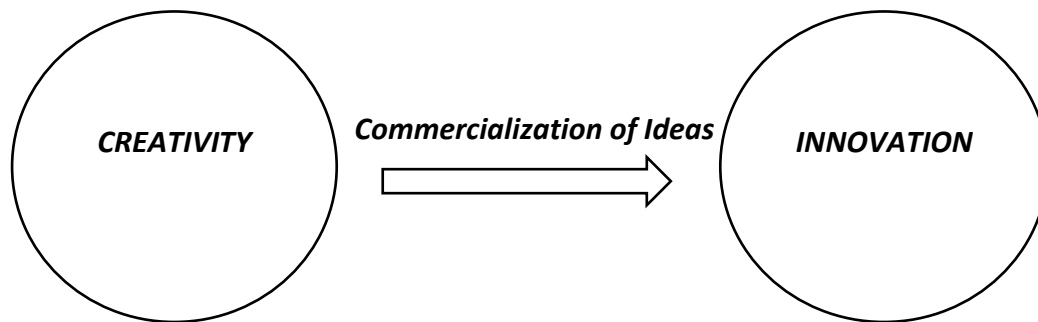


Figure 9: Relationship between Creativity and Innovation (after e.g. West, 2002)

It is also imperative to go deeper into the subject and discuss (a) why creativity is significant, and (b) what the different emphases on creativity in the different literatures are.

3.2 Significance of Creativity

Ford and Gioia (1995) state that *“creativity is simply essential, because organizations and their environments are both changing so fundamentally”* (p. 4). Indeed, there is abundant research arguing for the importance of studying, and advancing our understanding of, creativity; a notion which is of value to scholars and practitioners in numerous domains (Bissola and Imperatori, 2011; George, 2007). Creativity has been viewed as (a) a matter of life and death in our societies (Toynbee, 1962); (b) to the society’s advantage (*Ibid.*); (c) the pathway that enables us to respond to the constantly changing dynamic market pressures (Rickards, 1999); (d) a core necessity for organizational survival and success (Ford, 1995; Scott and Bruce, 1994); (e) a means to meet the demands of fierce global competition (Andriopoulos and Dawson, 2009; Kanter, 1984); (f) linked to employee satisfaction, welfare (Runco, 1995) and retention (Katz, 1964); (g) one of the substrata for the development of a competitive advantage (Amabile, 1988; Ford and Gioia, 1995; Magadley and Birdi, 2009; Martins and Shalley, 2011); (h) a means to gets new businesses started and sustain existing ones (Amabile and Khaire, 2008; Joyce *et al.*, 2010); and (i) the roadmap to organizational innovation and long-term commercial success (Amabile, 1983; Kristensson *et al.*, 2002; Prahalad and Ramaswamy, 2003). Today—more than ever—creativity has become a vital and an increasingly popular topic for investigation in a plethora of disciplines because of the opportunities afforded by the unstoppable technological advances, such as the ease in transferring knowledge and *going global* (Castells, 2001), as well as due to organizational change, unpredictable clienteles, and demanding employees (Andriopoulos and Dawson, 2009).

Corporations from a variety of industries highlight the significance of creativity. For instance, Apple Inc.—a leader in high-tech industry today (BloombergBusinessWeek, 2013)—has placed particular emphasis on the issue of creativity: *“Apple has managed to sustain its innovation efforts with calculated, consistent increases in R&D spending and rapid-fire launches of new products and upgrades. What lies behind Apple’s success is not luck—the company has very deliberately focused its efforts on generating better ideas faster”* (Quinn, 2010). It has also been asserted that Apple Inc. provides a work environment which is unconventional, and

supportive of creativity; and also open to all new ideas its employees may come up with (Mueller, 2010). Further to this, the next section presents different types and frameworks that can be found in the literature.

3.3 Types and Frameworks of Creativity

It is important to explain that there are different types of creativity, and therefore, the literature offers a number of frameworks that have been developed to describe creativity. Interestingly, in the organizational literature, Unsworth (2001) argues that creativity has been treated by scholars homogeneously; she, in contrast, suggests four different types of creativity (Figure 10).

		Engagement Driver	
		<i>External</i>	<i>Internal</i>
Problem Type	<i>Open</i>	Expected Creativity: Required Solution to Discovered Problem <i>E.g. creative artwork</i>	Proactive Creativity: Volunteered Solution to Discovered Problem <i>E.g. unprompted suggestions</i>
	<i>Closed</i>	Responsive Creativity: Required Solution to Specified Problem <i>E.g. Responses produced by think tank</i>	Contributory Creativity: Volunteered Solution to Specified Problem <i>E.g. Contribution by non-project member</i>

Figure 10: Matrix of Creativity Types (after Unsworth, 2001, p. 291)

By using two continua or dimensions—one concerned with the reasons for engaging in creativity, and the other concerned with the problem upon which creativity is predicated—Unsworth (2001) unearths four broad types of creativity. For instance, responsive creativity refers to a situation where the individual, externally driven, responds to a problem that has been presented to them. This type of creativity, argues Unsworth, is the most prevalent type of creativity in the literature. Diametrically opposite in this model features proactive creativity—the type of creativity that has been studied the least, and which refers to the situation whereby an individual, driven by internal factors, is in the lookout for problems to solve.

Expected creativity is the type of creativity that occurs in quality circles and total quality management in organizations; one that emerges via an external expectation. Lastly, contributory creativity constitutes a highly self-determined type of creativity that can be, for example, found when an organizational member becomes eager and, thus, engaged with a problem that they are not directly affiliated with.

A framework that has been used in the creativity literature is the *4Ps* of creativity—highlighting that creativity can be associated with four constructs: the person, with a large part of the literature pertaining to the view that creativity is associated with the person or the individual (discussed in detail later); the process (Koestler, 1964; Wallas, 1926), with the most popular that of Alex Osborn (1963); the product (Richards, 1999); and the effects of the press of the environment, with reference to both the physical environment and corporate issues (Smolensky and Kleiner, 1995).

Shalley and Gilson (2004) use the following way to classify different types of creativity: individual- (e.g. personality traits); job- (e.g. job characteristics, role expectations and roles, sufficient resources, rewards, supervisory support, external evaluation of work); team- (e.g. social context, group composition); and the organization-related (e.g. climate, human resource practices).

There also exist different foci of interests in the different literatures; some emphasize the individual dimension of creativity (Simon, 1988), while others the socio-cultural dimension (Csikszentmihalyi, 1999). In addition to that, the literature suggests that Small- and Medium-sized Enterprises (SMEs) seem to focus on individual creativity, as also do firms in the financial sector, while large firms, as well as organizations in the marketing and sales sector, place greater emphasis on organizational creativity (Bharadwaj and Menon, 2000).

Notwithstanding this, one of the most popular frameworks that have been used in the management and organizational literatures to investigate creativity is the individual-team-organizational one (Figure 11), which I will be using in order to organize the remainder of this chapter.

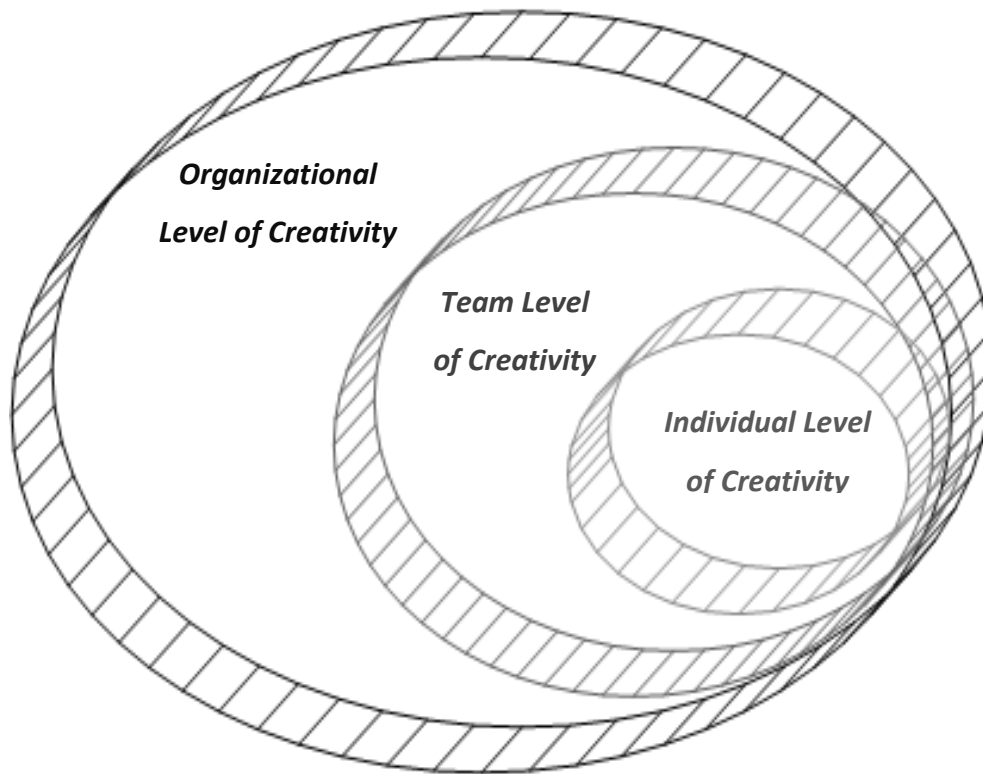


Figure 11: Three Levels of Creativity (after Chen, 2006; Thatcher and Brown, 2010)

In Figure 11 I show pictorially the three levels of creativity following existing literature arguing for the three levels of creativity: individual-team-organizational (e.g. Chen, 2006; Thatcher and Brown, 2010). Each of the three levels of creativity has been studied in its own right, but, as the framework shows, all three are highly intertwined, as they influence one another. For example, creativity at the team level is influenced by the individuals' creativity as well as by organizational factors. In the following section, I elaborate on the three levels of creativity in detail.

3.4 The Three Levels of Creativity

3.4.1 Individual Creativity

A large part of the creativity literature—especially at its early stages—has been concerned with creativity at the individual level. Individual creativity is undoubtedly important because it provides the substratum for organizational creativity and innovation (Amabile, 1988), and is closely associated with divergent thinking, or else the ability to produce a plethora of different ideas as opposed to a single answer, which might be the outcome of linear, or convergent, thinking (Thompson, 2003). On the one hand, researchers seem hesitant to answer why some individuals are more creative than others, or why some ideas are more ground-breaking than other, but yet there seems to be consensus over the view that a number of factors that influence one's ability to demonstrate creative behaviour. Based on this logic, for example, Guilford (1950) suggests that creative individuals possess abilities that can lead to noteworthy expression of creativity. They range from: (a) being more sensitive to problems, thus being curious and able to identify problems where others do not; to (b) being able to produce and synthesize ideas that are unusual but appropriate

On the other hand, a view that emerges from research into the individual level of creativity is that *all* individuals can be creative in certain domains (Kirton, 1994; Sternberg, 1999). As Amabile (1996a) also puts it, “... *all humans with normal capacities are able to produce at least moderately creative work in some domain...*” (p. 1). In essence, the forenamed scholars argue against the view of certain individuals being more or less creative; instead, they purport that there exist two dimensions (level or capacity, and style or preferred approach) along which all individuals are creative in different ways. For instance, an individual may be more or less creative in a specific domain due to manifest skill or knowledge, or as a result of an intellectual gift within a specific area. Similarly, there are differences in cognitive structure—the way individuals process their ideas—resulting in different types of creative outcomes. In what follows, a deeper look into the factors associated with the individual level of creativity will be taken.

Mumford *et al.* (2007), following this categorization, present in two rubrics the attributes that individuals possess (capacities) and what they have to be able to do (capabilities). The capacities are: expertise, creative thinking skills, social skills and organizational knowledge; and the capabilities: defining problems, establishing the context, and development and fielding.

Andriopoulos and Dawson (2009) summarize the following factors with reference to the individual level of creativity: cognitive factors, personality traits, relevant knowledge, and motivation. Regarding the cognitive factors, Torrance (1974) finds that fluency, mental flexibility, originality, and elaboration boost divergent thinking, and thereby individual creativity. Fluency refers to one's ability to articulate a large number of ideas in words. Mental flexibility concerns the ability to generate a variety of idea types, and the ability to shift from one approach to a different one. Originality is about ideas that are neither common nor obvious. Lastly, elaboration pertains to the level of detail characterizing each idea.

In a similar vein, freshness and suspension of judgement (Majaro, 1992), the ability to link remote associations (Mednick, 1962), intelligence (Amabile, 1998) are also cognitive factors associated with individual creativity. Personality traits too are seen as relevant. These can be risk-taking, self-confidence, tolerance of ambiguity, need for achievement, and autonomy and non-conformity, (Andriopoulos and Dawson, 2009), while surprisingly, though sometimes inherent, creativity can also be taught (Hokanson, 2007). For example, an experiment run by the latter using the verbal *Torrance Test of Creative Thinking (TTCT)*, a very widely used standardized test of creativity and divergent thinking (Torrance, 1974), posited significant differences in exhibiting creative behaviours in comparing students who attended a creativity class and students who did not. Von Stamm (2003) agrees with this view, as she finds creativity is a skill and not a personality issue, implying we are not born creative but instead we become.

Yet, the above alone do not suffice for creativity to flourish; knowledge is also instrumental. As, for example, Hunt has succinctly put it, “[c]reativity is not something where someone who has never worked in that field suddenly gets this

marvellous idea. Creativity is relating a concept to a particular body of knowledge. The existing body of knowledge is as vital as the novel idea and really creative people spend years and years acquiring and refining their knowledge base—be it music, mathematics, arts, sculpture or design” (Von Stamm, 2003, p. 2). Furthermore, motivation is another component of creativity, as creative individuals love what they do (Csikszentmihalyi, 1997). Motivation can be intrinsic or extrinsic and it may influence differently individual creativity in organizations (Amabile, 1997; Chamakiotis and Panteli, 2009). Grace, or divine inspiration, accident or serendipitous fortune, and association, or inability to turn things around, are, lastly, three additional factors associated with individual creativity (Henry, 1991).

Moreover, it is worth pointing towards the process whereby an individual captures, processes, and exhibits a creative idea. One of the most known creative process models is that of Graham Wallas, which involves preparation, incubation, illumination, and verification (Wallas, 1926; Wallas, 1976). Preparation refers to the stage when the individual conducts preparatory work on the dimensions of a certain problem, illumination, when the idea becomes conscious awareness, and verification, when said idea is being verified and elaborated. Interestingly, incubation, which features as the second stage in the creative process, entails the internalization of a problem into the unconscious, *ceteris paribus* in the external world of the individual. This view somewhat agrees with the assertion that creative solutions to problems emerge in a mysterious way from the unconscious, with the conscious being otherwise occupied (Anderson, 2005).

3.4.2 Team Creativity

It has been asserted that *“the average person can think up twice as many ideas when working with a group than when working alone”* (Osborn, 1957, p. 229). Following from Osborn’s (1957) view, creativity cannot be seen as an individual trait, but instead as the outcome of interpersonal interplay within a specific structure (Nemiro, 2002); team interaction has the potential to lead to better ideas (West, 1990), while Csikszentmihalyi (1996) even argues that creativity happens not by individuals in isolation, but through interaction. The suggestion above is grounded

on the assumption that individuals are more creative when in groups than when alone, due to their interactions. Or, in Csikszentmihalyi's (1996) words, *"an idea or product that deserves the label 'creative' arises from the synergy of many sources and not only from the mind of a single person"* (p. 23). However, this view has received substantial criticism and has been viewed by some as incorrect. Staw (2009), for example, argues a creative outcome is not insured when bringing individuals together in a group arrangement; rather, as he puts it, *"... there has been nearly total silence about whether the march toward team-based work has been beneficial or not. It is as though researchers have assumed that such a powerful management trend 'must' be effective, lest it would extinguish over time"* (p. 321).

Team or group creativity, or collaborative creativity (Herrmann, 2010; Mamykina *et al.*, 2002) as it has also been phrased, is unavoidably influenced by the individual creativity of its team members (as also shown in Figure 11). It is however influenced by such additional factors as group composition, group characteristics, and group processes (Woodman *et al.*, 1993). Besides, teams are about combining and integrating input from multiple individuals and, by so doing, create new knowledge and insights, given that effective communication is established; the more a team interacts, the more likely for an idea to cross-fertilize, which enhances the activity of idea generation in general (Csikszentmihalyi, 1996; West, 1990). But the team plays an important role in defining the social influences that affect individual creativity within it (Woodman *et al.*, 1993). It has been voiced, for example, that heterogeneity and diversity, or group composition are central to creative teamwork (Amabile, 1998; Woodman *et al.*, 1993). For example, when it comes to multidisciplinary teams, where highly heterogeneous individuals are involved, experience, and in fact different types of experience (Cummings and Kiesler, 2007), serves as a common ground for better creativity, knowledge sharing, and idea building. The issue of heterogeneity in teams has also been seen as troublesome. For instance, Ayoko *et al.* (2002) speak about communication accommodation theory and argue that, in culturally heterogeneous teams, individuals undergo a process of renegotiating their use of language and shared meanings in order to accomplish communication, which often leads to conflict.

On the other hand, feelings of trust and belongingness for the team members also feature as factors influencing team creativity (Andriopoulos, 2001; Woodman *et al.*, 1993). The factors influencing team creativity do not stop here though; leadership appears to be another important one, acknowledged by many (Amabile and Khair, 2008; Andriopoulos, 2001; Jung, 2001; Mumford *et al.*, 2002; Reiter-Palmon and Illies, 2004; Shalley and Gilson, 2004; Tierney *et al.*, 1999; Zhou and George, 2003); and is a topic that has been discussed in relationship with creativity (Amabile, 1988; Jauss and Dionne, 2003; Mumford *et al.*, 2007; Mumford *et al.*, 2002). Amabile and Khair (2008), interestingly, make the point that though it may be a challenging task for a leader to manage creativity, they can manage *for* creativity.

Despite potential advantages of nurturing creativity in teams, this is not without challenges, as certain psychological phenomena might preclude teams from attaining high degrees of creativity (Andriopoulos and Dawson, 2009). For instance, there is an inherent oxymoron when it comes to cohesion and creativity in teams. Staw (2009), specifically, distinguishes among scholars who see interaction patterns and social influences in groups as anathema to creativity, and others who consider cohesion the vehicle to creativity, and underlines the need for an environment wherein integration and differentiation coexist under the prevalence of a creative culture. Following from that, a number of paradoxes too have been identified in the literature when managing creativity (Andriopoulos, 2003), yet these will be presented and discussed in the following section that deals with the organizational level of creativity.

Additional hurdles seem to obscure creativity at the team level. Blind conformity, which refers to the human willingness to be liked by the rest, might lead to engaging in illogical behaviours (Thompson, 2003), while groupthink, group cohesiveness and group loyalty are likely to constrain debate and thus idea generation (Andriopoulos and Dawson, 2009). Free riding or social loafing, lastly, refers to instances when certain team members' performance is inhibited and therefore their contribution becomes limited (Thompson, 2003); this phenomenon implies that individuals are often not as productive when in groups as when alone, and this may be owed to

leadership insufficiency, motivation loss, equity of effort, or lack of personal responsibility (Kreitner *et al.*, 2002).

3.4.3 Organizational Creativity

Amabile (1996b) is among the first scholars who argued that further to personal characteristics warranting for creativity, the organizational environment has an important role to play. Organizational creativity is viewed as the interface between individual characteristics (e.g. personal competencies), group characteristics (e.g. group dynamics), and organizational characteristics (e.g. climate) (Paulus, 2000). Isaksen and Lauer (2002), for instance, outline the following factors in reviewing the literature on how climate influences creativity: challenge and involvement, freedom, trust and openness, idea time, playfulness and humour, conflict, idea support, debate, and risk-taking, while Andriopoulos (2001), in a broader picture, summarizes the five major organizational factors that can enhance creativity, as follows: organizational climate, leadership style, organizational culture, resources and skills, and structure and systems of an organization. Drawing on Andriopoulos's study, Kallio and Blomberg (2009) add more factors that influence organizational creativity. They argue in their review that the same factors can have a positive or negative effect upon creativity, depending on the attributes of the other factors as well as on environmental/situational influences. For example, in two different organizational climates, the same leadership style could have opposite effects on creativity.

Moreover, it is important to understand the context within which creativity is studied, as this can determine which creative outcomes can be measured (Mumford *et al.*, 2002; Shalley and Gilson, 2004). The factors that describe the context might include capabilities, pressures, resources, and socio-technical systems (Csikszentmihalyi, 1996). Given the context, creativity can be measured not only by the individual and/or the team, but also by stakeholders outside of the team, that is the manager or the customer (e.g. regarding products). Amabile also refers to context as a critical factor for creativity (Amabile, 1996b; Amabile *et al.*, 1996), although they do not offer a definition for it. This is why several researchers have identified such contextual factors (e.g. enhancers and inhibitors) as areas for future

research. Nonetheless, it is widely acknowledged that organizations which provide the tools, environment and context suitable for creativity to flourish, enjoy greater benefits from creative employees (Andriopoulos, 2001). Another common view among researchers is that expenses for creativity should be seen as an investment, as they result in increased turnover. Innately creative people alone are not sufficient for team and/or organizational creativity to flourish, but rather training is also necessary.

However, as introductorily mentioned earlier in section 3.4.2, a number of paradoxes are found to inhibit creativity at the team, but more relevantly at the organizational level. The paradoxes are:

- Support employees' passions, but achieve financial goals;
- Challenge employees, but build their confidence;
- Encourage personal initiative, but maintain a shared vision;
- Encourage diversity, but build cohesive work teams;
- Learn from the past, but seek new areas of knowledge; and
- Take incremental risks, but break new grounds (Andriopoulos, 2003).

Paradoxes, in this regard, lie in the opposing inherent tendencies between the employees themselves and their organization. Andriopoulos (2003) labels these paradoxes, yet they have not been rationalized. Lewis (2000) encourages future researchers to rationalize the paradox, develop a framework that can foster creativity, and interpret anomalies that occur in organizations, or as she puts it, to develop *"... understandings more in tune with the paradoxical nature of individuals, groups and organizational life"* (p. 774). As however this study is particularly concerned with the team level, the third and fourth paradoxes are likely to be of importance for this study, because they present an antiphrasis between the diversity of the individuals forming a team, and the overall cohesion of the team. These trace back to Staw's (2009) preoccupations described earlier.

Adding to the above, organizational change and organizational routines appear to be factors influencing creativity in organizations. Considering that change, defined in a

simple way as “*new ways of organizing and working*” (Andriopoulos and Dawson, 2009, p. 14) is nowadays inherent in organizational nature and also constant, this might perturb organizational routines and employees’ customs in their organizational life. Indeed, routines capture organizational change, but as it stems from the organizational literature, there are conflicting views as regards the relationship between creativity and routines (Dougherty, 2008). In her review, Dougherty (2008) finds that while some emphasize that creativity and innovation should be separate from routine work, others argue it should be integrated into it. Zhou and George (2003) are supportive of the former view and claim that creativity, by its very nature, is supposed to challenge the *status quo*, or the routines. Tsoukas and Chia (2002), on the other hand, disagree with this dichotomy and make the point that although organization represents an attempt to put human action into order, shape it, and formalize it, organization is at the same time constituted and shaped by change (which is commonly viewed as opposite to routine).

Following from this discussion on the three levels of creativity drawing on management, organizational and psychology literature, I turn to discuss creativity within the design context.

3.5 Creativity in Engineering Design

The importance of creativity in design is essential. For example, it is a common view among organizations that design engineers are creative and are often selected based on this assumption (Kemper and Sanders, 2001). Creativity in engineering in general is defined as *“the ability of human intelligence to produce original ideas and solutions using imagination”* (Drabkin, 1996, p. 78). Cropley and Cropley (2005) represent a large part of the design literature arguing for an output-based view of creativity in this field: *“engineering creativity is different from other fields like fine arts and it is clearly seen through the product, device, or system being developed by the engineers that perform the task or solve problems”* (p. 171). Generating ideas, or *good* ideas in fact, is therefore central to delivering a creative design output, as all creative outputs, tangible or not, find their roots in ideas that were *good* (Goldschmidt and Tatsa, 2005). Thus, there is some evidence within the design literature that idea generation is one of the most important elements in creativity in engineering.

There is also literature explicitly arguing for the importance of creativity within the field of design. For instance, creative products constitute an important source of corporate profit (Kim and McNair, 2009; Kim *et al.*, 2007). Also, creativity is one of the most significant criteria for the quality of a design (Christiaans and Venselaar, 2005). Creativity is also essential for any problem-solving activity within the design process (Casakin, 2007); it leads to easier and quicker problem-solving and helps the designer to identify further opportunities (Horowitz, 1999). It has also been stated that the success of the design industry in the USA is largely owed to creative thinking (Culver, 1990). A creative designer is capable of (a) generating solutions to technical problems quicker, thus speeding up the design process (Pahl and Beitz, 1984); and (b) influencing product development positively from the early stages, when a market need is identified, through to manufacturing and its successful completion (Court, 1998), thus insinuating that design creativity can also influence the commercial success of a product (Bruce and Cooper, 2000). As the forenamed scholars argue, products often fail when they are launched to the market because out of the, for

example, nine months of the product development process, only two weeks are spent on the conceptual phase, during which ideas are generated.

A question that nonetheless arises is whether all design outputs are creative, and, if so, to what extent. Design outputs can be classified as per their level of novelty: from original, when incorporating new solution principles; to adaptive, when embodying an established solution to satisfy new criteria; and variant, when altering certain aspects limited by previous design structures (Pahl and Beitz, 1984). Design types have also been classified according to their degree of creativity, as routine designs, innovative designs, and creative designs (Gero, 2001). Gero (2001) speaks of the design space and argued that creative designs shift the design space by introducing new factors, whereas innovative designs only require extra knowledge within the progenitor's space. It follows that not all design tasks require the same degree or type of creativity, but rather the design brief—the designer's starting point which ensures the output will cover customers' needs—plays a large part in defining the degree of creativity needed.

In view of the above, scholars in the field of design (e.g. Howard *et al.*, 2008) have borrowed frameworks from the psychology (e.g. Sternberg and Lubart, 1999) and other literatures in order to quantify, assess, and measure the level of creativity in their experiments. For instance, Reinig *et al.* (2007) suggest four ways to measure creativity, each with certain advantages and disadvantages: idea-count, sum-of-quality, average-quality, and good-idea-count. In the field of design, in particular, Shah *et al.* (2003) acknowledge the view that idea generation methods have systematically been adopted from a variety of sources and different fields, and propose four objective measures in order for design creativity to be assessed. They are: novelty (used to measure the degree to which a generated idea is unusual/unexpected in comparison with other ideas); variety (used to measure the solution space within which a designer can generate ideas); quality (used to measure a generated idea's feasibility and the degree to which it meets the design specifications); and quantity (used to measure the number of ideas, given that the more the generated ideas, the higher the chance for good ideas (Parnes, 1961)).

Hocevar (1981) summarizes ten categories of tests that have been developed to measure creativity: tests of divergent thinking, attitude and interest inventories, personality inventories, biographical inventories, teacher nominations, peer nominations, supervisor ratings, judgments of products, eminence, and self-reported creative activities and achievements. In a similar fashion, Cropley (2000) presents in a table the elements that have been used across different disciplines to gauge creativity in such tests (Table 6); he sees them as being associated with the product, the process, and the individual's motivation and personality.

Table 6: Elements Used to Measure Creativity (after Cropley, 2000, p. 77)

Product	Process	Motivation	Personality
<ul style="list-style-type: none"> • Originality • Relevance • Usefulness • Complexity • Understandability • Pleasingness • Elegance/Well-craftedness • Germinality 	<ul style="list-style-type: none"> • Uncensored perception and encoding of information • Fluency of ideas (large number of ideas) • Problem recognition and construction • Unusual combinations of ideas (remote associates, category combination, boundary breaking) • Construction of broad categories (accommodating) • Recognizing solutions (category selection) • Transformation and restructuring of ideas • Seeing implications • Elaborating and expanding Ideas • Self-directed evaluation of ideas 	<ul style="list-style-type: none"> • Goal-directedness • Fascination for a task or area • Resistance to premature closure • Risk-taking • Preference for asymmetry • Preference for complexity • Willingness to ask many (unusual) questions • Willingness to display results • Willingness to consult other people (but not simply to carry out orders) • Desire to go beyond the conventional 	<ul style="list-style-type: none"> • Active imagination • Flexibility • Curiosity • Independence • Acceptance of own differentness • Tolerance for ambiguity • Trust in own senses • Openness to sub-conscious material • Ability to work on several ideas simultaneously • Ability to restructure problems • Ability to abstract from the concrete

Largely, however, the design activity itself is considered an example of the creative process (Forest and Faucheux, 2011). It has also been argued that creativity is an integral part throughout the design process (Bruce and Bessant, 2002)—particularly prominent early on in the design process, during the conceptual phases (Cross, 2008; Hill, 1998; Vzyatishev, 1991). In their definition of the design process as “*a human activity, involving communication and creative thought among a group of participants*” (p. 291), Gennari and Reddy (2000) too embrace—and emphasize the significance of—the notion of creativity as an inherent aspect of design.

While there is agreement within the design literature that creativity matters the most during the early phases, i.e. conceptual phases, of the design process (e.g. Benami and Jin, 2002), recent literature has sought to examine creativity during the later phases of the design process. These studies posit the emergence of different design approaches, associated with an individual designer’s behaviour, and discuss their implications for creativity (Snider *et al.*, 2013).

Lastly, engineering has also been used in the management literature to explain the individual’s motivation for creativity. For instance, it has been reported that certain engineers have an internal drive to passionately and successfully be creative in their work; and that time pressure may have positive influence on an engineer’s creativity, by helping him/her focus better on the design s/he has been tasked with (Unsworth, 2001).

Following from section 3.1, whereby a definition of creativity as idea generation (Amabile, 1988) was adopted for the purposes of this thesis, and after consideration of the available methods for measuring creativity, as discussed in the earlier paragraphs, the method of idea-count (Reinig *et al.*, 2007)—used to gauge what other researchers have referred to as quantity of ideas (Parnes, 1961; Shah *et al.*, 2003)—was considered most suitable and was therefore adopted for this thesis.

3.6 Summary of the Creativity Literature

It follows from the review presented earlier that creativity constitutes a well-researched topic across different disciplines. It is without a doubt that organizations nowadays have placed much emphasis on supporting and enhancing creativity in order to develop a competitive advantage. What the literature review on creativity has shown is that: (a) creativity may be associated with different constructs (e.g. the individual, the process); and that (b) though its investigation initially took a focus on the individual level, creativity was later examined at the team and organizational levels. The design literature reviewed in this chapter demonstrates that creativity is pivotal in design, as it is closely linked to the problem-solving activity, as well as to the commercial success of a product, among other issues. Overall, the individual-team-organizational model will be used as a sensitizing device in order to enable an understanding of creativity in the context of VTs. Following, also, existing suggestions on measuring creativity, the idea-count approach emerging from this literature will also be used to study creativity in the context of this thesis. Next, I review what is known about creativity in the virtual context—in particular in VTs—by bringing the two literatures together.

Chapter 4: Theoretical Framework and Research Question

In this chapter, I bring the different literatures together and discuss what is known about creativity in Virtual Teams (VTs). By critiquing the literature, a number of gaps in our understanding in the field are brought to light, which I present next. In continuation, I develop a theoretical framework which will be used to drive this research henceforth, focusing on creativity in Virtual Design Teams (VDTs). Distilled from the theoretical framework is the revised Research Question (RQ) and objectives of the thesis.

4.1 Creativity in Virtual Teams: What do we know?

In this section, I discuss extant literature on creativity in VTs. Surprisingly, despite the wide, cross-disciplinary, therewithal, recognition of creativity being a vital issue in the light of global competition, very little is known about it in the context of VTs—let alone in the VDT context. In other words, despite the topicality of these issues, very few scholars have explicitly addressed creativity in VTs. Before I discuss some key findings from these studies pertaining to the subject, I shall first acknowledge that there are a few studies which have looked into creativity, and idea generation more specifically, in other computer-mediated, or digital, contexts—not in the context of VTs *per se*. For instance, Shirani *et al.* (1999) examine the effects of different levels of synchronicity on idea generation; they find that groups using rich Information and Communication Technologies (ICTs) (i.e. a prescribed Group Support System (GSS)) generate more basic ideas, whereas groups using lean ICTs (i.e. email) generate more inferential ideas. In addition, Kerr and Murthy (2004) argue that Computer-Mediated Communication (CMC) teams outperformed Face-to-Face (F2F) teams in the divergent aspect of creative tasks, while the opposite happened in the convergent aspect of similar tasks. Per Pissarra and Jesuino (2005), however, anonymity increased team performance in terms of numbers of generated ideas, because the use of CMC reduced the evaluation effect and the fear of disagreement.

Insofar as VTs are concerned, Ocker (2005) features as one of the most cited authors. By analysing the written communication transcripts of ten VTs, she unearthed a number of enhancers of, and inhibitors to, creativity in VTs. Her findings suggest that dominance, domain knowledge (technical and functional), external reward, time pressure, downward norm setting, structured approach, technical problems, lack of shared understanding, and non-stimulating team members are factors inhibiting creativity in VTs. For example, the presence of particularly dominant individuals in the VTs was found, in her study, to impede other participants' *voice* and input; the dominant participants minimized the level of interaction within their VT(s), made decisions for the whole team on their own, and wrote emails in a rather decisive manner, leaving very little room for additional input and ideas. Similarly, downward norm setting is a term describing a situation whereby a person adjusts (by lowering) his/her behaviour to match the performance level of the lower performing team members (Camacho and Paulus, 1995). What Ocker found is that the VTs—in which this phenomenon was posited—failed to collaborate as effectively as others and, most importantly, produced a significantly smaller number of ideas.

On the contrary, based on the same study (Ocker, 2005), stimulating colleagues, variety of social influences, setting the example, collaborative climate, and surface and reduced equivocality constitute factors that enhance creativity. In some more depth, Ocker observed that, in some VTs, some participants contributed to the development of a highly creative work environment by generating ideas themselves early on in the project's and VT's lifecycle. Rather than encouraging and supporting idea generation in a verbal way within their VTs, these individuals set the example by generating ideas themselves. In a similar vein, the VTs exhibiting a collaborative climate were focused entirely on defining and addressing the key tasks of the project as a team—they did not, as other teams, spent time giving unconstructive feedback on specific VT participants' individual performance. Chang (2011) pursued a study with graduate students in a similar asynchronous VT environment. He found that gender, nationality, social status, personality and communication styles were not associated with creativity. Rather, pertinent leadership, anonymity and equal

participation, a structured approach to idea generation, and recognition of outstanding performance acted as enhancers of creativity.

Moreover, Letaief *et al.* (2006) provide their own set of VT creativity enhancers and inhibitors, based on their study of 25 Global Virtual Teams (GVTs) from ten Universities dispersed across seven countries during an inter-University project. The inhibitors are: team lack of focus and dispersion due to multitasking (when team members were engaged in several projects simultaneously), lack of participation and not meeting deadlines (this included lack of motivation and differences in terms of time perceptions among different members), conflict avoidance for fear of reprisals (this was seen as harming GVT communication in general and the virtual character increased ambiguity), poor management of idea ownership (when a good idea was attributed to someone else rather than its original creator), and technical problems and technology insufficiency (system dysfunctions and technologies that did not meet the GVT members' needs). The enhancers are: presence of stimulating members (those who took the liberty to raise issues, and whose participation stimulated participation of other members too), ubiquity (pertinent time planning and distribution between different projects run simultaneously), technology appropriation (appropriating and managing technology suitably), and early emanation (a *Eureka* moment that may harmonize the GVT members early on).

Further to the studies offered by Ocker and Letaief *et al.* that, in essence, offer a set of VT creativity enhancers and inhibitors pertaining to the level of interaction within each VT, Ocker conducted in total four studies using data from three experiments involving 100 teams (summarized in Ocker, 2007b). Each of these studies looked at creativity from a different perspective; the first focused on the individual's personality, the second on team composition, and the third and fourth on team interaction. For instance—insofar as the individual's personality is concerned—Ocker found that the ideal participant for high VT creativity should be an imaginative and original thinker who is unafraid to express his/her ideas with enthusiasm, and who is preoccupied with ideas and not the final grade of the project (Ocker, 2008).

Further research has been conducted with regard to the individual level of creativity in VT settings. Martins and Shalley (2011), more specifically, explored the relationship between demographic differences (i.e. in terms of race, sex, age, and nationality). Interestingly, their findings suggest that differences in age interacted with (a) the processes of establishing rapport, participation equality, and conflict escalation, and with (b) differences in technical experience to influence creativity. Similarly, differences in nationality interacted with differences in technical experience to influence creativity negatively. In contrast, differences in gender and race did not exert a significance level of influence on creativity.

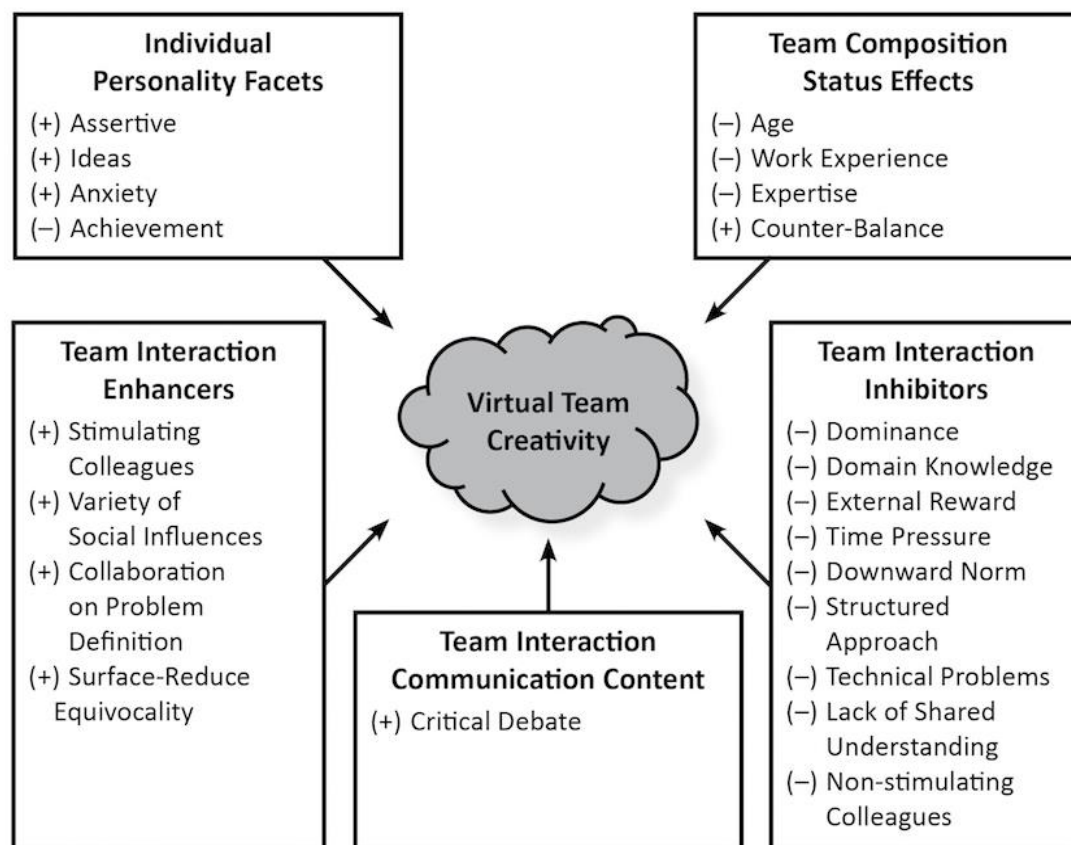


Figure 12: Factors Influencing Creativity in Asynchronous Virtual Teams (after Ocker, 2007b, p. 41); + = enhancers, - = inhibitors

Ocker makes a number of assertions: first, that VTs whose members communicate strictly asynchronously—i.e. no F2F communication or synchronous ICTs—are able to produce significantly more creative results; and that—within the context in which she studied creativity in VTs—the factors influencing creativity in virtual environments do not differ from the factors influencing creativity in traditional,

physically collocated environments. In a wider picture, her findings from these studies (Ocker, 2007a; Ocker, 2007b; Ocker, 2008; Ocker, 2005; Ocker and Fjermestad, 2008) are presented diagrammatically in Figure 12 above, and are classified per the foci of the studies she (and colleagues) conducted. The factors found to influence VT creativity positively (enhancers) are preceded by (+) and those influencing VT creativity negatively (inhibitors) are preceded by (-).

In addition to work presented above, Nemiro is another scholar who has conducted studies on the same topic, drawing on VT participants from different industries. She argues that, in order for high levels of creativity to be attained in a VT, each of the following five blocks should be in place: design, climate, resources, norms and protocols, and continual assessment and learning (Nemiro, 2007). First, design comprises: (a) a clearly structured creative process, for example, one consisting of the following stages: idea generation, development, finalization/closure, and evaluation (Nemiro, 2002); (b) a work approach that encourages good teamwork (for instance, a modular approach which is about parcelling out work within the VT based on individual expertise and preference); and (c) leadership structures that are germane to the VT in question (e.g. permanent or rotating leadership). Second, climate concerns: the level of connection attained by members within a VT—it is both task- (made up of dedication/commitment, and goal clarity) and interpersonal-related (made up of information sharing, trust, and personal bond) (Nemiro, 2001); and also team member and management conditions and competencies. These conditions include *“acceptance of ideas, constructive tension, challenge, collaboration, freedom, management encouragement, and sufficient resources and time”* (Nemiro, 2007, p. 110). Third, the building block resources refers to the availability of ICTs that are pertinent to the VT task. Fourth, norms and protocols should be in place to dictate what constitutes appropriate behaviour within a VT situation; often in VTs, remotely based VT participants become free insofar that they may permeate the boundaries characterizing traditional teams. Therefore, this fourth block is there to underline what the communication behaviour, and also what the project and task management are. Continual assessment and learning, the fifth

and last building block for creativity in VTs, should be in place to ensure that the momentum does not slow down as the VT lifecycle approaches the end.

Kratzer *et al.* (2006) investigate creative performance in a study of 44 VTs in the field of research and development. Their study takes a focus on three of the unique characteristics of VTs featured saliently in the literature—physical proximity, communication modality, and team task coordination—and examines whether variances in these three aspects are associated with creative performance, which they see as a combination of emerged ideas, applications, inventions, methods, and approaches, self-reported and -evaluated by the study participants themselves. The authors infer that the more variable each VT in each of these characteristics is, the more creative the performance of the VTs under investigation. In other words, teams that were constantly close in proximity or constantly distant were found to perform less creatively compared to teams that alternated between close and distant physical proximity.

Chamakiotis and Panteli (2009) assert that task-, technology-, individual-, and organization-related forces have had a significant impact on creativity in a global virtual organization in the sales and advertising industry. This study, based on interviews with 15 VT members, also contributes to our conceptual understanding of creativity in the virtual environment, but it does not name the exact circumstances under which these forces turn from enhancing to inhibiting or *vice versa*. As an example, their study found that the temporary and global character of the VT tasks had both an enabling and a constraining role for creativity; on the one hand, the global character offered higher degrees of autonomy for the VT participants to accomplish the tasks, but on the other hand, inhibiting forces lowered the VT participants' creativity, due to other organizational priorities (e.g. focus on profit).

Finally, a single study was identified, focusing explicitly on creativity in VDTs. Glier *et al.* (2011) conducted two controlled experiments involving VDTs and collocated design teams with the aims of evaluating the teams' ideas that were generated using different methods (brainstorming vs. modified 635 method). The generated ideas were assessed in terms of quantity, quality, novelty and variety and benchmarked

against the two methods used in the experiments. The authors infer that teams using the latter method produced similar numbers of ideas regardless of team distribution (distribution in their study is used to mean geographical separation). Teams using brainstorming to generate ideas produced higher quality ideas in a distributed environment, while novelty was rated higher by the researchers when the teams used brainstorming in F2F settings. This study is the only one identified in this specific area of research, yet it approaches the topic from an engineering design education perspective, aiming to confirm which creativity techniques work better in different (virtual vs. F2F) design team environments. Another limitation of their study is that it does so by following a top-down research approach, using preselected variables, and limiting thereby the potential for unpredictable findings in this controlled experiment.

Having reviewed what is known about creativity in VTs, I now turn to a discussion on what these studies do not show and on what is not known in this field overall.

4.2 Gaps in our Understanding of Creativity in Virtual Teams

In this section I critique the literature on Creativity in VTs presented above and I identify knowledge gaps. While, in the earlier section (4.1), I emphasized the—rather significant—contributions of the studies in the field of VT creativity, I now turn to unpack and discuss what these studies have not achieved. In other words, though these studies contribute some useful accounts of—and do advance our understanding around—creativity in VTs, significant lacunae still exist in the field.

First, none of the studies presented earlier in this chapter provide a clear definition of what the authors consider creativity to be. With no definition communicated formally to the reader (and possibly to the studies' participants), there is a high degree of ambiguity characterizing these findings. Another factor that limits our understanding of the topic is that the majority of these studies essentially offer factor-based models which ignore the role of the process the team(s) undergo. For example, Ocker unpacked a noteworthy number of factors influencing creativity, but it is unknown at what stage of the VT lifecycle and/or the creativity process each factor was found to influence the participants' creativity.

Importantly, most of these studies (Chang, 2011; Letaief *et al.*, 2006; Ocker, 2005) have been pursued in educational settings, where the researcher(s) used student-based VTs to answer their RQs. Despite the flexibility offered by such arrangements, using students raises significant concerns: First, student environments lack the dynamics of, and challenges entailed in, organizational environments. For example, issues of competition or power (Panteli and Tucker, 2009), as well as issues of simultaneous participation in multiple VT projects (Gibson and Gibbs, 2006), and/or constantly changing business focus/priorities and unexpected financial restrictions (Chamakiotis and Panteli, 2009)—issues that may exert significant influence on VT creativity—are typically absent in student-based VTs.

Further, the students in the VTs under investigation had clearly articulated tasks to accomplish in educational environments, where the researcher imposed the type of media (e.g. asynchronous media only: Chang, 2011; Ocker, 2005). This, again, limits the significance of the findings, as it may not be relevant to participants in VTs in

industry. In addition, participants in Ocker's studies were highly homogenous in terms of age, nationality and mother tongue; therefore, issues characterizing GVTs, in which the participants come from different countries and cultures, speak different languages, and work in different time zones, have been neglected in her studies.

Nemiro overcame with her research some of these limitations, as her studies drew on professionals—not on students. Still, however, her work is not domain-specific, as she used different teams of designers, consultants, and other professionals. Therefore, with the evidence gathered from the existing literature in the field, it cannot be argued with certainty which factors influence VT creativity in which domain.

Kratzer *et al.* (2006), following similar research that has looked at the relationship between innovation and virtuality (Gibson and Gibbs, 2006), discuss the relationship between creativity and virtuality. The scholars specifically adopt a top-down, deductive approach after pre-selecting three specific characteristics of virtual teams—in essence, geographical dispersion, CMC, and team coordination. Though they contribute interesting findings, their approach is a constraining one, as it pre-assumes which of the various unique characteristics of virtuality found in the VT literature may influence creativity in the VTs and therefore the potential influence all other characteristics (e.g. subgrouping, heterogeneity) are unavoidably neglected.

Glier *et al.* (2011) constitutes the only study available in the research literature, examining creativity in the specific context of VDTs. Yet, this study was conducted with the aim of improving engineering education and focused on VDTs in educational settings in which the participants were students. The scholars conducted two controlled experiments and compared and contrasted the effectiveness of different creativity techniques in teams operating in traditional (F2F) and virtual modes. Thus, their study was one that used VDTs as the empirical context for the investigation of something that is outside the scope of the literature on virtuality.

The relevance of findings emerging from literature focusing on idea generation in CMC environments (Kerr and Murthy, 2004; Pissarra and Jesuino, 2005; Shirani *et al.*,

1999) is also questionable in the VDT context for numerous reasons. For instance, these studies lack the dynamics of real VTs, as they are based on groups of individuals that were put together artificially for the purposes of an experiment. Thus, issues of geographical dispersion and heterogeneity, among others, were absent in these studies. In addition, the experiments were set up in a restrictive manner, allowing, for example, the use of either email or a GSS that was prescribed by the researchers, limiting thereby the spontaneity and ICT flexibility that is often encountered in real VTs. What is more, these were quantitative studies focusing on preselected variables, testing hypotheses, and not allowing for potentially significant data outside the strict scope of their studies to emerge.

There is no doubt that all these studies are important in the field. However, there is a major limitation characterizing the literature on VT creativity overall; that, with the exception of one study that makes the first step, and partially manages, to address this (Kratzer *et al.*, 2006), none of these other contributions explain what is unique about creativity in the context of VTs. In other words, some of these factors may even be identical to the factors influencing creativity in traditional work environments. For instance, the importance of a collaborative climate for creativity, posited by both Ocker and Nemiro as a factor influencing creativity in VTs, constitutes an already known factor influencing creativity in organizations whose teams work F2F (see for example Andriopoulos, 2001). Though this may be seen as providing another contribution—that (some of) the factors influencing creativity in traditional contexts are still important in the VT context—this does not show which, if any, of the unique characteristics of virtuality influence creativity in VTs. To make my point more explicit, physical collocation—a common characteristic of teamwork in traditional settings—has been seen as a factor enhancing creativity (Harms and Zee, 2013). In VTs—where physically collocated members are not commonly found, except in cases of locational subgrouping (Panteli and Davison, 2005)—it is likely that, and worth of investigating whether, geographical dispersion and subgrouping have a role to play instead.

This discussion of the limitations of relevant literature warrants that the topic of creativity in VTs deserves further attention. The criticism above brings to light important gaps that existing literature in the field has not addressed thus far.

4.3 Putting the Pieces Together: Theoretical Framework and Research Question

The cross-disciplinary literature review performed earlier points toward a knowledge gap in the area of creativity in VDTs. In brief, despite the significant works of a few IS and other scholars who have looked into this area, the extant literature does not provide adequate accounts of how creativity is influenced in the VT context. Figure 13 below encapsulates the knowledge obtained from the different literatures reviewed in this and earlier chapters.

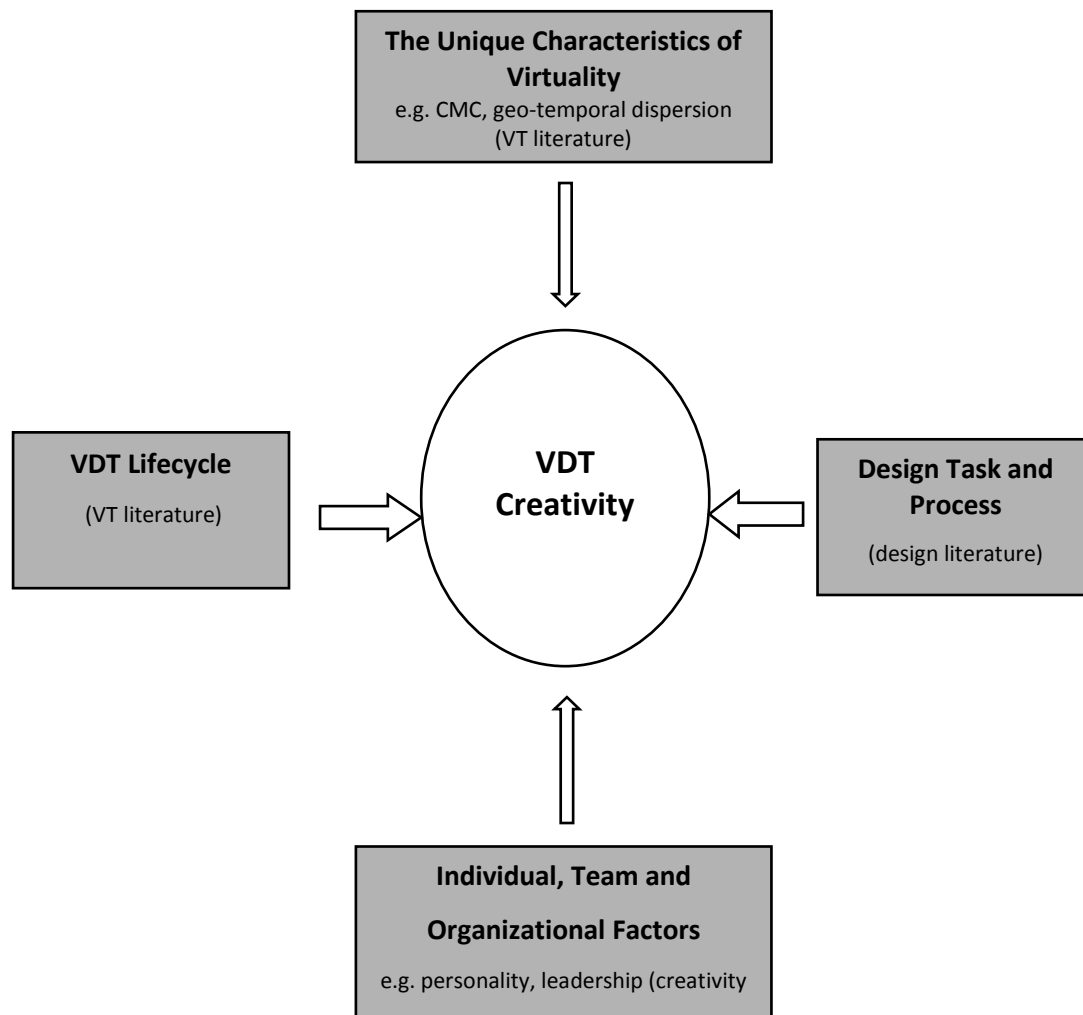


Figure 13: Understanding Creativity in VDTs: A Theoretical Framework

The theoretical framework (Figure 13) uses the team as a unit of analysis and assumes that creativity in the context of VDTs is influenced by individual, team, and organizational factors (as per literature on creativity), by the unique characteristics of virtuality (as per literature on VTs), and by the design task and process (literature on design), thus taking into account literature from all fields concerned. Though

there is evidence that some of the individual and team factors influencing creativity in traditional teams are significant in VTs (Ocker, 2007b), what remains to be examined is whether these are also significant in VDTs. More importantly, the unique characteristics of virtuality, including salient ones, like computer-mediation, and others, discussed in detail in Chapter 2, have not been examined in relationship with creativity in any context (VTs or VDTs), though these may exert significant influence on creativity. The framework underlines, therefore, this gap which I will be seeking to address with my empirical work (Chapters 6-8).

It has to be emphasized that while previous studies on VTs have looked at several issues (trust, leadership, etc.) as a means for improving their overall VT performance and effectiveness, the approach taken in this thesis is one that will look into creativity only without making associations between creativity and performance. Creativity is recognized as an important topic in numerous fields of study and my contribution lies in exploring creativity in the VDT context.

I must also reiterate that engineering design serves as the empirical, not a conceptual, context in this thesis. Therefore, though its importance is acknowledged in the theoretical framework, no attempt will be made in this thesis to study in depth the role of the design task and process, despite their significance, or measure the level of creativity of the design output. Rather, these constitute interesting and fertile areas for investigation, which future researchers from the design discipline could consider.

Importantly, though this too has been suggested several times in the thesis so far, it must be clarified that the work presented here is the first to examine creativity in VDTs aiming to contribute to the literature on virtuality. Considering, therefore, the newness of the topic overall, and as it will also be discussed in Chapter 5, where the espoused research approach will be detailed, my approach in conducting this research will not be a top-down one, aiming to test factors emerging from existing literature; rather, an open, bottom-up approach will be adopted, borrowing however accounts from existing literature, aiming to understand what is it that influences creativity in VDTs.

As it follows, the RQ distilled from the theoretical framework (Figure 13) is:

How is creativity influenced in temporary Virtual Design Teams (VDTs)?

The RQ is best understood through three intertwined research objectives which guided the research and are as follows:

- **Objective 1: To understand creativity within the VDT lifecycle**

Though the VT lifecycle has been posited in the relevant literature as one of the unique characteristics of virtuality, with scholars arguing that it raises implications for successful leadership (Bell and Kozlowski, 2002), among other issues, and despite the few studies that have focused on creativity in VTs, understanding creativity within the VT lifecycle is still to be examined. It is also important to conduct VT research by investigating a VT from start to finish in order to make sense of any factors emerging from the analysis (Clear, 2008), and, therefore, investigating a VT's lifecycle throughout is of critical importance when aiming to understand creativity within it.

- **Objective 2: To elicit factors influencing creativity in temporary VDTs**

The second objective relates to factors influencing creativity in the VDT context that may emanate from the traditional creativity literature or from prior work on VT creativity. Eliciting such factors is important, as it contributes to understanding whether these previously identified factors are relevant within the context of my thesis. More importantly, eliciting factors influencing creativity in VDTs is not considered a conclusive objective. Rather, I will be looking for factors which I will use as a device enabling better understanding of creativity in VDTs, focusing on *how* creativity is influenced in this unique context. Thus, any reference to factors from this point on will serve this purpose. One of the questions used in the analysis to promote understanding of how creativity is influenced using identified factors might be: What type of influence is exerted by each factor? It is possible that certain factors enhance and others inhibit creativity. It may also be the case that certain factors have a twofold role to play, both enhancing and inhibiting

creativity under different circumstances or in different contexts. To answer the above, an open approach is needed that will allow a plethora of factors to emerge, regardless of them being associated with the creativity or other prior literature, given that creativity in VDTs has not been previously examined. Prior literature on creativity offers large sets of factors that are seen as associated with creativity in traditional, F2F team environments. To date, it is unknown which of these factors are significant in the virtual, or VDT more specifically, context. The objective, here, is therefore to elicit factors that are transferable to, and significant in, the VDT context, thus core factors influencing creativity in any context—F2F, virtual or VDT.

- **Objective 3: To explain how the unique characteristics of virtuality influence creativity**

Contrary to Objective 2, Objective 3 seeks to unpack and explain the relationship between creativity and virtuality. Despite the few studies available on VT creativity, discussed earlier (e.g. Ocker's studies), it is unknown how virtuality itself influences creativity in VTs or VDTs. For example, factors emerging from these studies are factors that may be relevant to any context, be it F2F or virtual. And though the VT literature outlines specific characteristics, what I herein refer to as unique characteristics of virtuality, these have not been discussed in relationship with creativity. In particular, issues of dispersion and subgrouping, as well as the role of CMC for creativity, among others, are expected to be scrutinized. The earlier section, outlining some of the gaps in our understanding of creativity in VTs (4.2), highlighted that certain characteristics (e.g. CMC, geo-temporal dispersion) have been acknowledged in the VT literature, and yet their role for creativity has not been examined. My objective is therefore to advance understanding of the role played by the unique characteristics of virtuality for creativity in the context of VDTs.

4.4 Onward

So far, I have presented a cross-disciplinary literature review on VTs (Chapter 2) and creativity (Chapter 3) that led to the development of a theoretical framework (Chapter 4, Figure 13) and a revised RQ followed by three objectives that guide the remainder of this thesis. Next, in Chapter 5, I present the research approach adopted to address the RQ.

Chapter 5: Research Approach

In this chapter, I present the research approach I developed to answer the Research Question (RQ):

How is creativity influenced in temporary Virtual Design Teams (VDTs)?

The term *research approach* is used to mean the epistemological and ontological stance adopted, paired with the selection of methodology, and the chosen data collection and analysis methods. The selection of these is based on the type of RQ and the availability of approaches in management and Information Systems (IS) research. I then present, and explain the role of, the three case studies that were conducted, discuss the characteristics of the teams under investigation and outline the research sites' suitability.

5.1 Research Stance: Philosophy of Science and Paradigms

Not all researchers make the same epistemological and ontological assumptions; these may differ according to the field, the type of research, and the nature of the research aims and/or RQ. Epistemology—a term that originates from the Greek term *ἐπιστήμη* (*episteme*)—refers to the manner in which we come to know. This is closely related to the concept of ontology—the philosophy of reality. In any research, it is important that these terms are clarified and used appositely. As Healy and Perry (2000) put it, “... *ontology is the ‘reality’ that researchers investigate, epistemology is the relationship between that reality and the researcher, and methodology is the technique used by the researcher to investigate that reality*” (p. 119).

There exist numerous classifications of the different epistemological positions that have been adopted by scholars. For instance, Duberley *et al.* (2012) use the following umbrella terms to classify some prominent epistemological positions in the organizational literature: positivism, qualitative neo-positivism, interpretivism, critical theory, postmodernism and poststructuralism, and postcolonialism and indigenous epistemologies. Easterby-Smith *et al.* (2002) present positivism and social

constructionism as two dominant ontologies in management research and discuss different research approaches surrounding them. The most popular, and also diametrically opposite, epistemological paradigms are positivism and interpretivism and their properties and implications are summarized in Table 7 below.

Table 7: The Two Paradigms

	Positivism	Interpretivism
Ontological	Reality is external and objective	Reality is subjective and socially constructed
Epistemological	Knowledge is absolute	Knowledge is relative
Axiological	Unbiased and objective	Biased and subjective
Rhetorical	Formal and Impersonal	Informal and personal
Outset	Hypotheses Development	Research Question
Methodological	Deductive and Static	Inductive and dynamic
Technique	Measurement	Conversation
Analysis	Verification/Falsification	Sense-making
Outcomes	Causality	Improved Understanding

In many fields, dominance of positivist positions is posited. In the IS discipline, the following epistemological positions have been identified: positivism, interpretivism, critical realism (Orlikowski and Baroudi, 1991) and, in the subsections that follow, I present a review of these three positions.

5.1.1 Positivism

“Positivism is properly an epistemological stance that proposes that the social world can be described in terms of the law-like generalizations, of an identical form to those in the natural sciences, and that knowledge can therefore be acquired through the collection of value-free facts” (Nandhakumar and Jones, 1997, p. 110). Advocates of the positivist paradigm believe that science offers access to a single, absolute and objective reality; per this view, the world is characterized by clear laws of cause and effect and the researcher’s role is typically to put together an experiment, conduct observations and quantitative measurements, and, using deductive or top-down reasoning, test his/her hypotheses (Krauss, 2005). It is for this why positivism is standard in the natural sciences. Positivists claim that their observations and approach are value-free and that an apprehensible access to truth can be gained through research (Healy and Perry, 2000).

Importantly, it has been asserted that the two main characteristics of the positivist paradigm are that: (a) research focus should be on objectively measurable phenomena, dismissing the investigation of intangible and subjective elements; and (b) research should test theories in a hypothetico-deductive fashion, benchmarked against facts gathered from an external reality (Duberley *et al.*, 2012; Keat and Urry, 2011). Espousing such hypothetico-deductive approaches, whereby the researcher develops *a priori* hypotheses with the aim of testing, observing and measuring, and, ultimately, drawing largely generalizable conclusions, is also known as *Erklären*, following the German term (Outhwaite, 1975). Unavoidably, such an approach, explicitly known for ignoring anything intangible and subjective, may be unsuitable when researching phenomena involving humans and their behaviours. In this regard, positivists treat any study’s participants as independent, non-reflective objects, ignoring their ability—and value thereof—to reflect on situations and act upon them interdependently (Robson, 2002).

There are two major limitations characterizing positivism, which have been acknowledged by other scholars too (e.g. Denzin and Lincoln, 2000; Orlikowski and Baroudi, 1991), and which I discuss here in order to show that it does not feature as

a germane position for the research of this thesis. First, positivism ignores social, political, contextual, historical and economic factors surrounding a situation which may be of paramount value for the investigation of such phenomena as the one studied here. Second, it is guided by the assumption that deterministic relationships typify reality and social structures, thus implying that individuals are not dynamic actors in the physical or social reality in which they exist, but rather their actions are pre-determined by external factors. This view contradicts the stance I adopt in this thesis, that the relationship between technology and people is a non-deterministic one.

5.1.2 Critical Realism

Critical realism is a paradigm that has been seen as accommodating opposing philosophical stances by combining elements from different paradigms, including positivism. While positivism argues for a single, fully apprehensible reality, and interpretivism, as I will be discussing later, advocates that there exist multiple, socially constructed realities, critical realists hold that there are multiple perceptions about one single reality (Krauss, 2005). More specifically, critical realism embraces the view that, consistent with positivism, an objectively knowable, mind-independent reality exists; however, it is asserted that this cannot be apprehended fully or perfectly (Guba and Lincoln, 1994). Critical realism is becoming common in a number of fields, among which are organization studies (Sayer, 2000) and IS (Mingers, 2004). One of this paradigm's strengths is that it offers a flexible approach regarding the methodologies that can be used within it, while it also *"... addresses both natural and social science and thus encompasses the main domains of IS"* (Mingers, 2004, p. 97). However, there are several disadvantages associated with this position. For instance, it has been criticized because the type of knowledge that emerges from such a position is ambiguous and uncertain: *"Critical theorists do not share common philosophical standards for the evaluation of theories. What is acceptable theory or explanation is still debatable"* (Chua, 1986, p. 626). Critical realism has not been adopted in this thesis, as its ontological assumptions about the existence of a single objective reality were not consistent with my background and

stance; nor, most importantly, with the non-deterministic, and socially constructed, view of the phenomenon of creativity in VDTs.

5.1.3 Interpretivism

Interpretivism, which has been chosen in this thesis, is an epistemological paradigm predicated upon a social constructivism ontology (Habermas, 1970). It accepts that individuals make sense of reality through sharing their experiences with one another via language (Shotter, 1993). Interpretivism and social construction theories are therefore diametrically opposite to the paradigms of positivism and critical realism which view reality as something objective. Interpretivists argue that *“reality is determined by people rather than by objective and external factors. Hence, the task of the social scientist should not be to gather facts and measure how often certain patterns occur, but to appreciate the different constructions and meanings that people place upon their experience. The focus should be on what people, individually and collectively, are thinking and feeling, and attention should be paid to the ways they communicate with each other, whether verbally or non-verbally”* (Easterby-Smith *et al.*, 2002, p. 30).

Interpretive research originates from the field of sociology (Schutz, 1962) and advocates that world existence lies in the meaning, language, reflective thought and interaction among individual actors; a view opposite to that of positivists who see world formation as reliant upon external factors. Contrary to the German term *Erklären* used to describe positivism, insinuating that research shall have the aim to explain, or to clarify, the German term used in interpretivism is *Verstehen*, suggesting that scholars adopting an interpretive position aim to understand (Outhwaite, 1975; Schutz, 1962). Therefore, the interpretive researcher’s task is to interpret the meaning that is being generated and shared among social actors within a social system (Orlikowski and Baroudi, 1991).

However, interpretivism is not unequivocal, nor are all interpretivists guided by the same principles; different research traditions, as to how the researcher can come to make sense of a phenomenon and assign meaning to it, exist within it. Common techniques to attain that include: empathetic identification, phenomenological

sociology and language games (Schwandt, 2000). Empathetic identification, or intentionalism, is based on the premise that the researcher can break out of his/her circumstances and assign meaning to a situation involving other actors (Dilthey, 1972). Similarly, those guided by social phenomenology within the interpretive paradigm attempt to “... *reconstruct the genesis of the objective meanings of action in the intersubjective communication of individuals in the social life-world*” (Outhwaite, 1975, p. 91). Language games constitute another interpretive tradition, according to which, human action can be understood through the language metaphor (Winch, 2002). As, more succinctly, Schwandt (2000) puts it, “*human action is meaningful by virtue of the system of meanings [...] to which it belongs*” (p. 192). Thus, interpretivism offers a plethora of traditions which can be espoused by the researcher in order that they can make sense of the phenomena they investigate. The viewpoint espoused here is to understand, and generating meaning about, the actions of actors involved in the situations studied (Golafshani, 2003).

Traditionally, a hegemony of positivist epistemological stances have been posited in many fields, including IS (Orlikowski and Baroudi, 1991) and engineering design (Hayes, 2010) research. As Hayes (2010) claims, the focus in design research is on artifacts (and their components, systems, processes and functions), and, therefore, design scholars typically espouse an objective ontology, a positivist epistemology, and quantitative methodologies. Orlikowski and Baroudi (1991) argue that a limitation of the positivist stance in IS research is that it neglects contextual and other factors that surround IS phenomena, thus leading to incomplete conclusions: “*The design and use of information technology in organizations, in particular, is intrinsically embedded in social-contexts marked by time, locale, politics and culture. Neglecting these influences may reveal an incomplete picture of IS phenomena*” (p. 12).

The philosophical stance espoused in this thesis is that of interpretivism, whose characteristics are outlined in Table 7 and juxtaposed with the diametrically opposite and more dominant in most fields philosophical stance; positivism. The use of interpretive enquiry is considered pertinent for a number of reasons. First, the issue under investigation is one that has received limited attention in the literature. Thus,

an approach that is open to the emergence of new themes regarding the phenomenon, rather than one that limits it, would warrant a better understanding of it. In other words, rather than hypothesizing what may be significant about creativity in the context of VDTs based on similar literature, my approach is one that can give way to unprecedented findings generated through interaction between the researcher (myself) and the participants in my studies. Second, the topic of creativity in VDTs is one that takes a focus on human beings, their behaviours and their interactions. Therefore, the participants' input and perceptions as to what is it that influences creativity in VDTs is necessary in order for an understanding of the phenomenon to be attained. Thus, interpretivism is seen as the paradigm that favours a better understanding of the phenomenon under investigation. Discussed next is the topic of methodology.

5.2 Methodology and Implications

Although the same methodologies can be used differently, depending on the philosophical position of the researcher (e.g. a qualitative methodology can be selected in an interpretivist or a positivist study for different purposes), the selection of methodology and the way it is used have to be consistent with the epistemological and ontological assumptions of any research (e.g. Bryman, 2008a). Methodology concerns the methods the researcher has selected in order to attain some knowledge of reality (Krauss, 2005). Quantitative approaches are typically deductive in nature, and their aim is to predict or control through the use of pre-selected variables in an objective, value-free manner; thus, quantitative scholars—strongly aligned with positivism—hold that an external, objective reality exists and their research methods are selected so that they reach that reality (Creswell, 2009; Robson, 2002).

Issues of validity, reliability and generalizability are of concern to positivist researchers employing quantitative methodologies (Tobin and Begley, 2004). Triangulation is one of the most popular evaluation criteria for quantitative research within the positivist paradigm. Triangulation can take several forms: from data source triangulation, where the researcher looks for cross-contextual data validity, and investigator triangulation, where different researchers look at the same phenomenon with the aim of generating similar results, through to theory triangulation, where the researcher looks at his/her dataset from different theoretical viewpoints, and methodological triangulation where the researcher combines different methodological approaches for the investigation of the same phenomenon (Denzin, 2009). Other types of triangulation posited in the literature are triangulation using different unit of analysis, e.g. interdisciplinary triangulation, conceptual triangulation, and collaborative triangulation (Tobin and Begley, 2004). Other evaluation criteria for quantitative research include reliability—the extent to which a measurement remains the same over changes of times or context; and validity—whether the research methods adopted measure what they are supposed to measure (Golafshani, 2003).

In contrast, qualitative research centres on the study of social and cultural phenomena and—contrary to quantitative which was initially developed to study natural phenomena—qualitative research usually addresses *what*, *why* and *how* questions and not *how many* or *how much* (Keegan, 2009). As Corbin and Strauss (2008) argue, qualitative research is “*a process of examining and interpreting data in order to elicit meaning, gain understanding, and develop empirical knowledge*” (p. 1). Thus, it is pertinent when the researcher aims to improve our understanding of a specific phenomenon, and it is very well suited to the exploration of research areas which have not seen much focus (Keegan, 2009), or when aiming at “*exploring and understanding the meaning individuals or groups ascribe to a social or human problem*” (Creswell, 2009, p. 4). Qualitative research may be deductive in character, but, uniquely, it can be performed in an inductive fashion, allowing theories to emerge from the data without the need for predefined codes or frameworks from the literature (Saunders *et al.*, 2009). Grounded theory constitutes an example of a completely inductive approach (Glaser and Strauss, 1967; Strauss *et al.*, 1990).

Lately, scholars from a number of disciplines have started to embrace the mixed methods approach, involving both quantitative and qualitative elements (Bryman, 2008b; Creswell, 2009). As Johnson and Onwuegbuzie (2004) put it, “*mixed methods research is formally defined here as the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study*” (p. 17). Though, however, the mixed methods approach is seen as a means for overcoming the weaknesses of either of the single quantitative or qualitative approaches, by combining the strengths of both, it raises concerns regarding the researcher’s ontological and epistemological position (Creswell, 2009).

Notably, there is an increasing body of literature employing qualitative methodologies within the field of virtuality. More specifically, qualitative approaches have been employed by IS scholars to study a number of issues in a number of virtual settings. These issues vary and include: the study of enterprise systems (Ignatiadis and Nandhakumar, 2007); identity in dating website environments (Light *et al.*, 2008); digital gaming media convergence and social networking websites

(Griffiths and Light, 2008); presence in blogs (Panteli *et al.*, 2011) and in Virtual Teams (VTs) (Panteli, 2004a); as well as richness in email communication (Panteli, 2002); virtuality in teams (Dixon and Panteli, 2010); business strategic conflict in Computer-Mediated Communication (CMC) (Lee and Panteli, 2010).

It is also important to highlight that qualitative research is not only about the methods used by the researcher, but it goes well beyond that, for example regarding the role of the researcher in the data collection and analysis, as well as in the findings writing-up and presentation stages. For example, the practice of reflexivity—the researcher’s assessment of their own influence over the interpretation of their data—as opposed to neutrality which is the case in quantitative studies, must be acknowledged in qualitative research (Ruby, 1980). In addition, one of the idiosyncrasies in qualitative research, and misunderstood issues in certain fields of study, particularly in fields that have been traditionally concerned with positivism, is the voice (active vs. passive) and the person (first vs. third) used by the author. Such elements are important in academic writing, because they are used as differentiators for the readership to distinguish the author’s line of argument from the different types of evidence they make use of (Holliday, 2002). It follows, therefore, that this is not only a matter of personal preference, but there are also underlying philosophical issues that regard the so-called authorial voice, or authorial *I*, and which should not be ignored when doing research. While, for instance, in the natural sciences and in positivism in general the researcher’s task is to report objectively the data as they are in reality, social construction theories do not accept unbiased objective research; rather, the author is seen as a stable coexisting figure, involved in the construction of the text (Tierney, 1997), whose self, values, gender, nationality, and experiences have an impact on the way the data are collected, analysed and, ultimately, presented (Onwuegbuzie and Leech, 2007).

In qualitative research, it is the researcher that serves as the instrument for data collection and any *a priori* biases or assumptions might influence the behaviour of the humans under investigation (Onwuegbuzie and Leech, 2007). This applies to the analysis and writing phases too. For instance, when the text represents one version of reality and not the one and only version of it, as it clearly happens with

interpretivism, the data undergo major reconfiguration, and the author has to use his/her voice to indicate s/he has been involved in the construction of the text (Richardson, 2000; Tierney, 1997). The use of the authorial *I* also shows that the author takes responsibility of his/her interpretations and arguments. As Hyland (2002), for example, succinctly puts it, “... [scholars] gain credibility by projecting an identity invested with individual authority, displaying confidence in their evaluations and commitment to their ideas. Perhaps the most visible manifestation of such an authorial identity is the use of first person pronouns and their corresponding determiners” (p. 1091). Unsurprisingly, therefore, an increasing volume of literature and doctoral work—also in disciplines such as design—has emerged, which has begun to make use of the authorial *I* in view of the above (e.g. Hey, 2008).

Different evaluation criteria are used in qualitative research when compared to quantitative methodologies, and these are highly linked to the epistemological and ontological assumptions (most commonly, interpretivism) associated with it (Correa, 2013). For Johnson *et al.* (2006), for instance, qualitative scholars should consider a set of evaluation criteria that are germane to qualitative research, rather than espousing criteria from the quantitative realm which is largely associated with positivist traditions and may therefore undermine—rather than strengthen—research findings. It has also been argued that—as opposed to quantitative research—issues of establishing validity and reliability are not significant in qualitative studies (Krauss, 2005; Tobin and Begley, 2004). Instead, the issue of reliability is best understood as trustworthiness in qualitative research (Golafshani, 2003), whereas others take issue with the relevance of the issues of reliability and validity in qualitative research and see them as completely irrelevant (e.g. Stenbacka, 2001). Rather than paying attention to what constitutes good quantitative research, Onwuegbuzie and Leech (2007) refute the significance of quantitative evaluation criteria in this realm of research and suggest that qualitative researchers be conscious about threats to the credibility of their findings, which might include observational bias and accuracy of the events being described, among others. Correa (2013) goes further and argues that evaluation criteria should not be used for issues

of exclusion in academia, but rather as an inter-disciplinary dialogue which is still in progress.

There also exist opposing views regarding triangulation and dependability in qualitative research. On the one hand, some argue that the use of different data collection methods (e.g. interviews coupled with observations) should be used to determine and confirm the accuracy of research findings, thus as a confirmatory device (Lewis, 2009). On the other hand, however, there is an dominant line of thought that views triangulation as inconsistent with the epistemological and ontological assumptions underlying qualitative research, advocating that completeness—instead of triangulation—should be aimed through the employment of different methods in qualitative research (Krefting, 1991; Tobin and Begley, 2004). It is, further, argued that completeness recognizes the view that multiple realities exist and refutes the notion of corroboration, implied when triangulating, which insinuates that a single objective reality exists, along the lines of positivism (Johnson *et al.*, 2006). Though different data collection methods are used in this thesis, discussed later in 5.4, these are not used as a confirmatory device, but rather, for completeness purposes, aiming to contribute richer accounts of the phenomenon under investigation. Insofar as dependability is concerned, though replication may be the case in quantitative studies, this is seen as problematic and unsought for in qualitative research, whereby the research findings are dependent upon the social context in which the study has been conducted. Thus, though there is no expectation for replication of qualitative findings, the researcher still has an obligation to clearly describe the context within which their study took place, and explain how their findings emerged (Johnson *et al.*, 2006; Krefting, 1991; Miles and Huberman, 1994).

Another important aspect is ethics, which refers to “... *the appropriateness of [the researcher’s] behaviour in relation to the rights of those who become the subject of [the researcher’s] work, or are affected by it*” (Saunders *et al.*, 2009, p. 130). Ethics is an increasingly vital issue when dealing with people in organizations and more importantly when dealing with sensitive issues about them. Ethics is particularly relevant in business contexts, as sensitive information that has not been anonymized may endanger one’s position in a corporation; this may be owed to individuals often

clashing their personal and professional interests (Punch, 1986). Ethical issues might concern anonymity, confidentiality, and informed consent (Senese, 1997).

As it follows from the discussion earlier, a qualitative methodological approach has been selected for the research in this thesis. This is consistent with the type of the RQ and my ontological and epistemological position described earlier (in 5.1). Having selected a qualitative approach also brings about important considerations for this research. For example, the qualitative approach within case study research is suitable for understanding the phenomenon within its context, offering theoretical insights of general value; yet, it may not be appropriate for statistical generalizations across different contexts and populations.

I now turn to a discussion on the selected research strategy.

5.3 Research Strategy: Case Study

Research strategies include surveys, case studies, ethnography, and action research, among others (Saunders *et al.*, 2009). However, it is important that a research strategy be selected carefully in view of the RQ. Among the various research strategies in management and IS research—such as action research, where the researcher is an active participant; ethnographies where the data are interpreted through the participants' eyes; or surveys which are more quantitative in nature and are usually inconsistent with interpretive epistemologies—the case study approach has been selected as a research strategy for the research presented in this thesis, for reasons I outline below. It follows that, in this thesis, I use the term *case study* to refer to a research strategy, following management scholarship (e.g. Eisenhardt, 1989; Yin, 2003), and not to a mere industrial example, which is what the engineering community commonly use the same term for. A discussion as to why this approach was selected follows.

Case studies are germane when *why* or *how* questions are to be answered and when the phenomena under investigation are of complex nature and are embraced by a social real-life context (Yin, 2003). They are known for their flexibility and for allowing the researcher(s) to study a phenomenon in its natural context (Weick, 1984). An accepted definition for a case study (as a research strategy) is “*the development of detailed, intensive knowledge about a single ‘case’*” (Robson, 2002, p. 40). Though case studies are oftentimes used to provide detailed descriptions of certain phenomena within the context in which they occur (Eisenhardt, 1989), it is also expected that researchers employing the case research strategy convey their case studies' potential excitement by moving beyond mere descriptions of the phenomena under investigation (Siggelkow, 2007). This way, researchers can show through case studies that their findings are important despite the weaknesses pertaining to case study research in general. Yet, despite being context-specific, case studies provide the means for the examination of human behaviour that may be applicable within other contexts too (Bryman, 1989). Some of the main characteristics of case study research are summarized as follows:

- *“Phenomenon is examined in a natural setting;*
- *Data are collected by multiple means;*
- *One or few entities (person, group, or organization) are examined;*
- *The complexity of the unit is studied intensively;*
- *Case studies are more suitable for the exploration, classification and hypothesis development stages of the knowledge building process; the investigator should have a receptive attitude towards exploration;*
- *No experimental controls or manipulation are involved;*
- *The investigator may not specify the set of independent and dependent variables in advance;*
- *The results derived depend heavily on the integrative powers of the investigator;*
- *[...]*
- *Case research is useful in the study of ‘why’ and ‘how’ questions because these deal with operational links to be traced over time rather than with frequency or incidence; and*
- *The focus is on contemporary events” (Benbasat et al., 1987, p. 371).*

Yin (2003) distinguishes among three different types of case studies: exploratory, descriptive, and explanatory, depending on the research purpose. Exploratory case studies aim to investigate a phenomenon during its early stages of investigation; descriptive require theory development prior to conducting the actual case study; and explanatory focus on causal investigations (*Ibid.*). Given the exploratory purpose of the research reported in this thesis, all case studies were exploratory in character, but each served a different purpose (explained later in this section as well as in 5.6). Further, case studies can be classified as follows: intrinsic, when the scholar takes a personal interest in the case study; instrumental, when the scholar aims to gain a deep level of understanding; and collective, when cases are examined at a group level (Stake, 1995). Per this classification, the approach taken here falls within the second category. Case studies can also be classified to single or multiple, and as holistic or embedded (Yin, 2003). A single case study concerns the investigation of a single case (e.g. an organization) with the aims of describing, discovering or testing

(Markus, 1989) and its main strength is that it permits an in-depth understanding of the phenomenon under study (Dyer and Wilkins, 1991). The case itself serves as the research setting, while within it may exist several instances of the phenomenon being investigated (Yin, 2008). Multiple case studies, on the other hand, may not be as rich as single case studies, yet they offer the opportunity to elicit findings that are unrelated to the idiosyncrasies that occur in a single research setting (Miles and Huberman, 1994). Researchers have also identified a set of different analytical techniques pertaining to case study research, for within- and cross-case analysis (Eisenhardt, 1989). Holistic case studies are those with one unit of analysis, while embedded case studies can contain multiple levels of analysis (Yin, 2003).

The case study approach offers several advantages when compared with other approaches. Notably, case studies are known for their versatile and pluralistic nature (Cavaye, 1996). For example, case studies can be conducted following a positivist or an interpretive stance depending on the research purpose (*ibid.*). Lee (1989) suggests that, traditionally, case studies have been conducted to generate initial theory for later testing. Cavaye (1996) argues that case studies in IS research have been used to describe phenomena, build theory, and also test existing theory, depending on the research purpose. Mintzberg (1979) believes that case study research aiming to describe phenomena comprises two stages: detective work and creative leap. The former involves data collection and initial analysis, during which the research themes begin to take shape, whereas the latter concerns the theoretical conclusions drawn.

Another strength of case study research is that it allows the researcher to employ multiple data collection methods, resulting in the collection of rich datasets, which can allow for an in-depth investigation of a phenomenon within its context. These can be quantitative and/or qualitative, separately or jointly for the same study. It has been argued that commonly in case study research the researcher(s) collect both types of data, though the quantitative ones may be restricted to frequency counts or ranking (Cavaye, 1996). A common view regarding the two methodologies (quantitative vs. qualitative) within case study research is that at the initial, exploratory stages of examining a phenomenon, qualitative approaches are more

suitable, whereas quantitative methods can follow for the collection of data focused on specific variables derived from findings that have emerged from qualitative analysis (Gable, 1994). However, as I also explain later in 5.5, quantitative techniques, such as tabulating numerical data, can be employed within a qualitative case study if the aim is to generate meaning of the phenomenon under consideration (Yin, 1981).

What is more, case studies are flexible insofar that they offer platforms for the investigation of a large number of variables, different facets of the phenomenon under investigation, and there is no need for prior knowledge of said phenomenon (Cavaye, 1996). Multiple case studies offer furthermore the opportunity to relate differences in findings to the context within each case study takes place (*Ibid.*).

Though it has been argued that case studies are not suitable for statistical generalization (e.g. Cavaye, 1996), relevant literature takes issue with this view, arguing that case study research offers other types of generalization: moderatum generalization—ability to make speculative associations; naturalistic generalization—generating meaning about something that was not known; analytical refinement—making associations from experience and observation to theory, rather than from sample to population; and isomorphic learning—learning from unique incidents that may or may not reoccur in a different context (Buchanan, 2012). In a similar vein, it has been argued that though the question of whether generalization can be attained through case study research has become a vociferous one, the answer is that case study research offers the following types of generalization: development of concepts, generation of theory, drawing of specific implications, and contributions of rich insights (Walsham, 1995). For example, the concept of *informed* environments is one that emerged and gained popularity in the IS literature from interpretive case study research (Zuboff, 1989). Thus, relevant literature outlines significant advantages offered by this research strategy that, in essence, outweigh its inability to provide the basis for statistical generalization. In this thesis, generalization is attained through my case studies to theory, not to a population, consistent with qualitative case study research (Eisenhardt and Graebner, 2007).

Overall, the advantages of case study research have been also juxtaposed to those offered by other research strategies, i.e. survey and experiment. It follows from these comparisons that case studies are best suited at the exploratory phases of a phenomenon, when other strategies may fall short in achieving similar levels of in-depth analysis (Gable, 1994). An example comparison is provided in Table 8.

Table 8: Case Study Research Strengths (after Gable, 1994, p. 11)

	Case Study	Survey	Experiment
Controllability	Low	Medium	High
Deductability	Low	Medium	High
Repeatability	Low	Medium	High
Generalizability	Low	High	Medium
Explorability	High	Medium	Low
Representability	High	Medium	Low

The discussion above shows, what several management and IS scholars have posited (e.g. Eisenhardt and Graebner, 2007; Yin, 2003), the multifaceted character of case study research and the plurality and versatility it offers to the researcher; from single (for richer understanding) to multiple (for comparisons and context-independent conclusions) case studies; from inductive (when wanting to generate theory) to deductive (when testing theory) functions; and from qualitative (when aiming for understanding) to quantitative (when aiming for measuring) methods, and any combination of the above, used within it. It is important, however, to state that no research strategy comes without its weaknesses. For instance, scholars are agreed on the inability of case study research to provide statistical generalization. The added difficulty for researchers adopting quantitative methodologies is that have “... *no control over independent variables and this may limit the internal validity of any conclusions. Also, [case study research] [...] cannot always indicate the direction of causation*” (Cavaye, 1996, p. 229). Notwithstanding these accounts, the case study approach was considered the most pertinent one given the exploratory character of the RQ along with the need for an improved understanding of creativity in VDTs. Further, considering Objective 1 of the thesis—to position creativity within the VDT

lifecycle—it was important to select an approach that would allow me to look into teams' lifecycles from start to end; clearly, the case study approach was the most flexible in this regard. Thus, though case studies carry limitations, as do all other alternatives, it was believed that the advantages offered by the case study approach outweigh its weaknesses, and it is for this why it was selected.

Three case studies have been conducted for this thesis. Study 1 was exploratory in character, aiming to explore creativity in VDTs in a student-based VDT context throughout the VDT lifecycle, and identify factors influencing creativity. Study 2 sought to investigate creativity in VDTs in a similar (student-based) VDT context through an enhanced methodological approach, whereby both interview and non-participant observation data played a similar role in the analysis (these methods are discussed in the next section, 5.4). This aimed to take a closer look into issues that were more closely related to virtuality. Study 3 was a comparative case study in industry; thus, its purpose was twofold. On the one hand, it aimed to extend the knowledge gained by the two earlier case studies to a different context, the industrial. On the other hand, its comparative character enabled me to unearth differences in creativity owed to virtuality, through a comparison between a Face-to-Face (F2F) and a VDT project. Building on discussions on theoretical sampling within case studies (Eisenhardt and Graebner, 2007) and qualitative research in general (Glaser and Strauss, 1967), Urquhart *et al.* (2010; 2012) suggest two diametrically opposite strategies depending on the researcher's aims: if the research aims to deepen theory in the study field, then he/she should minimize the dissimilarities in the groups studied and maximize their similarities; if, on the contrary, s/he aim to broaden theory, then s/he should maximize the dissimilarities and minimize the similarities of the groups under study. In this work, though I acknowledge the dissimilarities characterizing the different VDTs between the different case studies, I draw the similarities together with the aim of deepening theory in the field.

It follows that both educational and industrial contexts have been used in this thesis. Though most of the VT literature is based on the investigation of student-based VTs, and therefore my aim was initially to focus on organizational teams, educational contexts were found to be more easily accessible in comparison with industry, and it

is for this why Studies 1 and 2 were conducted in educational settings. This hybrid approach has been used in previous VT research (e.g. Bjørn and Ngwenyama, 2010) and in design research as well (e.g. Hey, 2008).

Presented next are the data collection methods used in the case studies.

5.4 Data Collection Methods

Case study research allows for the use of multiple data collection methods, which I have adopted in my thesis. In Table 9, I outline the main strengths and weaknesses of two of the data collection methods adopted here.

Table 9: Data Collection Methods in Case Study Research (after Yin, 2008, p. 80)

Source	Strengths	Weaknesses
Interviews	<ul style="list-style-type: none">• Targeted—focuses on case study topic• Insightful—provides perceived causal inferences	<ul style="list-style-type: none">• Bias due to poor questions• Response bias• Incomplete recollection• Reflexivity—interviewee expresses what interviewer wants to hear
Direct Observations	<ul style="list-style-type: none">• Reality—covers events in real time• Contextual—covers event context	<ul style="list-style-type: none">• Time-consuming• Selectivity—might miss facts• Reflexivity—observer's presence might cause change• Cost—observers need time

The following data collection methods were used in this thesis: interviews, recorded non-participant observations, collection of visual data (i.e. videos, photographic data, design outputs), and collection of other outputs (i.e. written communications) and documents (e.g. design briefs, project documentation). Overall, using multiple data collection methods softened the individual weaknesses characterizing each data collection method when used independently. For example, though data that could have led to useful insights might have been missed during my observations, interviews may have acted as a redeeming element, covering material that may have been unintentionally neglected. Before discussing the selected data collection methods in more depth, it is vital that I clarify that collecting different types of data was not done for triangulation purposes, as it would be the case in positivist studies, but rather in order to paint a richer picture of the phenomenon under study and attain a high level of completeness in my research, in line with interpretivism and my discussion in 5.2).

5.4.1 Interviews

Interviews can take various forms: from structured and semi-structured to completely unstructured, and from individual to focus groups (Robson, 2002). Interviews represent purposeful discussions between two (i.e. interviewer-interviewee) or more (i.e. focus groups) individuals with the aim of gathering trustworthy data which aid the research objective (Kahn and Cannell, 1957). Churchill (1999) argues that in exploratory research, in-depth, semi-structured interviews are fruitful. Thus, considering that the RQ of this thesis aims to explore creativity in VDTs, open-ended, semi-structured interviews were conducted with all participants.

I specifically adopted a semi-structured approach which gave the participants a stimulus for discussion on issues relating to my study. Example questions include: *“How did you go about creativity in this project;” “Was this project different to others you have taken part in the past;” “Why don’t you give me an example about how...;”* Therefore, questions were asked in an open, non-leading manner—often starting with *How* or *What do you think*—for two reasons: (a) to allow the interviewees to elaborate on issues that I may have not considered or otherwise captured (i.e. through another dataset), largely allowing the interviewees themselves to guide the remainder of the interviews; and (b) in an attempt to reduce the researcher’s bias, by not being constraining in the way the questions were being asked (Easterby-Smith *et al.*, 2002).

In Study 1, focus group interviews (up to seven interviewees) as well as individual interviews were conducted. Focus group interviews are suitable when wanting to create a pleasant environment for the interviews, while aiming for a forum with high diversity and low commonality of ideas (Keegan, 2009). I therefore conducted focus group interviews at the early stages of the VDT lifecycle, where my aim was to stimulate discussion and get some insight into the case study, and also in the last phase, where there were severe time constraints and it would have been impossible to conduct individual interviews with such a large number of participants. All interviews in the thesis were digitally recorded and varied in length, lasting between

20 and 60 minutes. The location of each interview varied; in Study 1 most interviews were conducted F2F in meeting rooms at the participating Universities in London, UK and Ljubljana, Slovenia as well as in a conference venue in Croatia. A small number of interviews were conducted via Skype. In Studies 2 and 3 all interviews were individual and were conducted in University meeting rooms and in the research site in which Study 3 was pursued, providing quiet, confidential and comfortable environments for the interviewees.

5.4.2 Observations and Visual Data

Observation is usually defined as watching individuals' behaviour in a specific context (Robson, 2002). Two types of observation are posited in research into the social sciences: structured and unstructured (Pretzlik, 1994); which have also been phrased as formal and informal (Robson, 2002). On the one hand, structured observation is most common in positivist research, whereby the researcher aims to record human behaviour. Researchers following this approach have selected what aspects of their observations to look into, prior to the observations, and everything that falls outside the scope of these aspects is considered irrelevant. On the other hand, unstructured observation is more consistent with the interpretive paradigm and is one that acknowledges the significance of the role of the context and that of the researcher in shaping reality between him/herself and the researched (Mulhall, 2003). Researchers conducting unstructured observations aim to collect rich information about the phenomenon under investigation, which will enable them to develop a better understanding of it. Thus, they have limited preconceptions as to what their observations might entail (Robson, 2002).

While in studies where structured observation has been employed as a data collection method the aim is usually for the researcher to be separated from the researched, thus maintaining a more objective stance toward the phenomenon and the individuals involved, consistent with the positivist paradigm, this is not always the case in unstructured observations. Interpretive researchers, arguing that it is highly unlikely to separate themselves completely from the researched, and that their presence is likely to have an influence on their participants' actions, may

commonly adopt a participative role in their observations. Therefore, there is a continuum across which a researcher might place him/herself. Their role may vary from that of the complete participant through to that of a complete observer, with participation as observer and observer as participant occupying the middle positions along the spectrum (Figure 14).

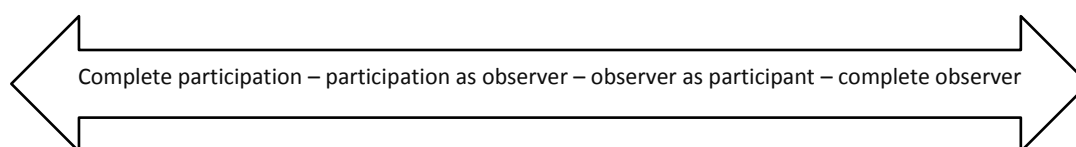


Figure 14: Observation Continuum (after Junker, 1960; Kawulich, 2005)

While all types of observation allow the researcher to collect rich data, each type has certain advantages and disadvantages. For instance, participant observation—on the left side of the continuum (Figure 14)—allows for data collection in a direct manner (McCall and Simmons, 1969), offering the chance for collection of data with minimal distortion, through interaction of the researcher with the researched (Kluchkohn, 1940). In this thesis, I conducted non-participant observations—the position of the complete observer in Figure 14. During my non-participant observations, I interacted minimally with the participants, mainly by asking questions about several aspects of the tasks they were undertaking. Though non-participant observations are more consistent with the positivist paradigm, as mentioned earlier, researchers conducting non-participant observations can still employ interpretive, qualitative approaches, which I have done in this thesis.

What is unique about non-participant, or passive, as it has also been referred to, observation is that it offers the researcher the means to observe human behaviour as it naturally occurs (Zechmeister *et al.*, 2006). Thus, it offers a competitive advantage when compared to other such methods as interviews or surveys, in which the data are filtered by the individuals being researched. When compared to participant observation, non-participant observation again is advantageous, as the researcher is not found to interact with the research participants or have significant levels of influence over their behaviours.

In my thesis, I conducted non-participant observations in all three case studies. My intention was to be a passive observer, with minimal (if any) influence over the

participants' activity and outcome. In Study 1 these were unrecorded and their main purpose was for me to develop familiarity with, and understand the context of, the project and teams studied. In Studies 2 and 3, however, my observations were recorded and captured the team's activity with the aim of reviewing and analysing the generated videos at a later point. Overall, my observations' aim was to familiarize myself with the projects and develop an understanding of the teams' activities that would enable me to understand how creativity was influenced within these contexts. During my observations, I also (a) took notes in a logbook that helped me remember important events for the visual analysis stage; (b) gathered photographic data by taking pictures of the teams as they worked and also by taking screenshots of the videos; and (c) collected the hard copies of the teams' concepts and ideas. Further to the videos I recorded myself, the participants themselves contributed to video generation through Panotpo—a software program that I instructed them to install in order to record their screen activity.

Recent literature is supportive of collecting visual data in IS (Urquhart and Vaast, 2012), management and organization studies (Meyer *et al.*, 2013). These approaches vary in terms of five key aspects: relevance, nature, producer, interpreter, and research focus (*Ibid.*). Two approaches were taken in this thesis; insofar as my recorded observations are concerned, I was the one to produce and interpret the recordings. This was the case in most of Study 2, and the first component of Study 3 where the team worked F2F. However, this was not the case in the virtual component of Study 3, in which the participants were geographically dispersed and it was not possible for me to record them. As Schultze and Orlikowski (2010) recognize, in a virtual environment, such as the one studied here, data collection may be a challenging process given that study participants are usually geographically dispersed. Therefore, though I was the one ascribing meaning to the videos, it was the participants (predominantly two out of three in Study 3) that produced them, following specific guidelines.

The generated visual data were stored on a secure, networked, and University-administered server provided for research purposes, and also on my own password-

protected MacBook, ensuring confidentiality of the information contained in these data.

5.4.3 Documents, Design Outputs, and Communication Extracts

Documents and archives are often considered complementary to interviews and observations in interpretive qualitative research, as they contribute insights that cannot be otherwise revealed, thus providing potentially rich accounts about the phenomena under study (Nandhakumar and Jones, 1997; Orlikowski and Baroudi, 1991). In this thesis, several documents were reviewed in my aim to increase my understanding of the projects in which the teams under study participated. For instance, for Studies 1 and 2, I collected information given to the participants by their Universities, outlining the content, structure, guidelines, and expectations of the project. In addition, for Study 1, I collected the assessment sheets produced by those marking the students at different phases as the project developed. These were emailed to me by the organizers of the projects of Studies 1 and 2 as they happened.

Further, I collected the generated design outputs during my observations (Study 2) and after the project (Study 3). These involved (a) sketches on flipchart papers the participants produced in brainstorming sessions and also individually, and (b) post-it notes with ideas generated by the participants at different point during the VDT lifecycle. For Study 3, these were collected in an electronic form; I specifically instructed the participants to save their design outputs in an electronic form in Dropbox folder—that they created for the purposes of their project in order to share their ideas with one another—to which I was later allowed access.

Finally, I collected all electronic communications between members in Studies 2 and 3. Specifically, Study 2 participants emailed me all emails and Skype Instant Messaging (IM) exchanged. In Study 3, I created a designated email account which the participants carbon copied in every time they emailed each other. They also saved all their Skype IM transcripts in Word files which they saved in our joint Dropbox folder after completion of the project for me to access.

Having discussed the data collection methods, I now turn to the methods used for data analysis.

5.5 Data Analysis Methods

Here I present the data analysis methods I adopted to analyse the collected data.

5.5.1 Visual Analysis

Visual analysis has been used to analyse the material collected through my recorded observations (Studies 2 and 3) as well as the videos recorded by the participants themselves (Study 3). Visual analysis has been gaining popularity lately within several fields of study, including IS (Urquhart and Vaast, 2012), management science (Meyer *et al.*, 2013) and design (Cash *et al.*, 2014). It embraces different datasets, most commonly video diaries and also photographic data, but also, more recently, digital texts, threads, social network newsfeeds and wikis, among many others (Meyer *et al.*, 2013; Urquhart and Vaast, 2012). Some scholars have used visual methods in order to inform their interview design and others as an independent analytical approach. Overall, there is agreement in this emerging body of literature that visual analysis provides useful insights into, and increased understanding of, the phenomena under study that is difficult to attain with other methods (Purchase *et al.*, 2008).

In my thesis, visual analysis involved videos and photographic data emerging from the videos of my recorded observations and those recorded by the participants themselves, as well as of the design outputs produced by the participants. My aim in analysing the videos was twofold: (a) to complement the interview data by adding to what influences creativity in the context of temporary VDTs; and (b) to position creativity within the VDT lifecycle. Therefore, while the former aim was seen as complementary to existing datasets, the latter was the only way to address Objective 1 of my thesis. The videos were watched several times for familiarization purposes (especially those produced by the participants themselves, which I had not observed in person myself). Large part of this visual analysis was guided by my own observations and notes I had taken in a logbook, as the VDT projects unfolded, in order to remind myself of important events, decisions and timestamps. Analysis of the videos followed a chronological view in line with Pettigrew's (1997) definition of *the process*: "... a sequence of individual and collective events, actions, and activities

unfolding over time in context” (p. 338) in order for creativity to understand creativity within the VDT lifecycle. The videos were subsequently coded manually on flipchart papers and later on Excel spreadsheets for better presentation. Though I reviewed available software programs, none were proved suitable because of compatibility issues and disadvantages that outweighed their advantages given the purposes of my research. In fulfilling the first aim of video analysis (i.e. to complement the interview data), I looked for management issues influencing creativity, in particular virtuality-related issues. These were highlighted in blue colour (Figure 15) and selectively transcribed verbatim quotes were produced for inclusion in the analysis. Once identified, these management issues were analysed thematically, as I explain in the following section, 5.5.2. I also identified and counted all design-related ideas the participants generated in order to position creativity within the VDT lifecycle. These related to whole concepts and/or design features/elements. In the spreadsheets—an excerpt of which is provided in Figure 15 below (see more details in Appendix G for both Studies 2 and 3)—design ideas are shown in red colour and are placed under the activity during which they were produced, e.g. brainstorming session or Video-Conference (VC) meeting. Further to the activity during which each idea was produced, the Excel spreadsheet also shows the medium (if not F2F) through which they were produced and also the timeslot. These are shown in different colours, explained in Appendix H.

One of the strengths of these visual data is that they contained most of the VDT activity from start to end of each project, enabling me to position creativity within the VDT lifecycle in Studies 2 and 3. Lack of similar data for Study 1 did not allow me to follow the same approach for that study, but still, an impression of where creativity was positioned in the teams studied in Study 1 was developed based on my interpretation of the participants’ interview data and my limited (unrecorded) observations.

The above-described approach of counting design-related generated ideas and positioning them within the VDT lifecycle of each team echoes a quantitative approach. As it was mentioned earlier in 5.3, case studies allow for both qualitative and quantitative approaches, both independently and also in a mixed fashion. Given

that an idea count is a quantitative technique, and due to Objective 1 of the thesis, employing a quantitative technique within my overall qualitative thesis was considered necessary and it was performed in a manner that is considered acceptable in qualitative research. For instance, Yin (1981) argues that numbering, counting, coding numerically, or tabulating quantitative data within a qualitative case study is acceptable when these techniques are adopted as a means for generating meaning.

TIME/SLOT	13:00-14:45	14:45-15:15	15:15-15:45	15:45-16:30	16:30-17:10	17:10-17:20	17:20-19:00		
MAIN ACTIVITY	INTRO/ORGANIZATION	VC/MEETING 2	BRAINSTORMING	VC/MEETING 3	BREAK	SKYPE/VC 3	BRAINSTORMING		
COMMUNICATION MEDIUM							H		
DATASOURCE									
IDEAS/ISSUES	ENERGY HARVESTING FROM BICYCLING	BADGES	CONCEPT	TIME		OBJECT	INTERNET/SEARCH	REMINDER	CONCEPT/ORG
	SMART/EVERYTHING SMART BIKE	FLAG	OBJECT	COMM		COMM	GREEN/STATIONERY	ELECTRICITY	MULTITASKING
	AN ECO-CITIZEN OBJECT	TASK	MATERIALS	CONCEPT		AESTHETICS	ECO-FRIENDLY/DIFFERENT PRODUCTS	MAGNETS	MULTIFUNCTIONAL
	THE CREATION OF A MULTI-PURPOSE BAR/BIOSKI*	FUNCTIONALITY	COMPOSTER	OBJECT		BIN	COMMERCIAL/POWERSAVER	ROTATION	TIME
	VEGETATION/CLEARING MACHINES/DRIED LEAVES	TIME	COLLECTION	TIME		PRESS		POSITIVE/REINFORCEMENT	REMINDER
	CARBON COOLER	COMM	REUSE	COMM		MONITORING		MONITOR	REMINDER
	A BURNING/REUSE/RECYCLING/COMPUTER		TREE	MATERIALS		PRESS		TREE/FOREST/GREEN	ELECTRICITY
			MONITORING	COMPOSTER		ROBOT		FUN/SONG	MAGNETS
				COLLECTION		MATERIALS		PHYSICAL/REWARD	ROTATION
				REUSE				SONG	MESSAGE
				TREE				EMOTIONAL/REWARD	JARGON
				MONITORING				KITTEN	FUN
				INTRO				COMIC	TIME
				WORK/DISTR				RECYCLED MATERIALS	POSITIVE/REINFORCEMENT
				WORK/DISTR					MONITOR
				TIME					TIME
									TREE/FOREST/GREEN
									FUN/SONG
									PHYSICAL/REWARD
									SONG
								EMOTIONAL/REWARD	
								KITTEN	
								COMIC	
								RECYCLED MATERIALS	
								TIME	
								ECO/CITIZEN	
								TIME	
								POSITIVE/ASPECT	
								DYNAMISM	

Figure 15: Excerpt of Observations/Video Analysis in Spreadsheet (Colour coding is explained in Appendix H)

5.5.2 Thematic Analysis

Thematic analysis has been used in psychology, sociology, economics, among other fields (Crabtree, 1992). It “... *allows the collection or use of qualitative information in a manner facilitating communication with a broad audience of other scholars or researchers*” (Boyatzis, 1998, p. 5). Thematic analysis can take many forms; it may be used in deductive studies of positivist character, where the researcher is after indicators and evidence signalling support for their theory (Boyatzis, 1998). However, thematic analysis is a term that though it has been widely used (Boyatzis, 1998; Roulston, 2001), there is very little information in the literature as to what it entails or what it actually is. Traditionally, thematic analysis has been seen as an analytical tool (not a method in its own right) that is embraced within certain data analysis methods (Boyatzis, 1998; Ryan and Bernard, 2003). Indeed, much of the coding that occurs in such data analysis methods as grounded theory, content analysis, or discourse analysis—all popular qualitative data analysis methods—is admittedly thematic in character. However, in this thesis I adopt the view that thematic analysis constitutes a data analysis method in its own right (Braun and Clarke, 2006) and in what follows I explain how it was conducted.

According to the forenamed scholars, thematic analysis comprises the following steps: data familiarization, initial coding, theme literature search, theme revision, theme definition and naming, and report production (Braun and Clarke, 2006). Data familiarization involves reading and re-reading data and generating initial ideas about them. Coding is initially open and aims at grouping together different parts of a dataset. At that stage, QSR NVivo 9—a popular software program used for organization and analysis of qualitative data—proved useful. Coding emanates from grounded theory as introduced by Glaser and Strauss (1967) and constitutes an established, multifaceted data analysis methods within IS research (Urquhart and Fernández, 2013). Initially, grounded theory sought to generate an in-depth understanding of the phenomena under investigation assuming that theory is to be discovered in, and extracted from, the data (Glaser and Strauss, 1967); a completely inductive data analysis method which has received substantial criticism (e.g. Bryant, 2002), as it is often impossible not to have any theoretical preconceptions and

develop theory purely from data (Urquhart and Fernández, 2013). Rather, grounded theory is a pertinent method when little or no theory exists. In fact, relevant literature highlights that grounded theory has been used impertinently in different literatures, including attempts to justify the researcher's lack of familiarization with the literature, or as an excuse to present raw, highly unprocessed data (Suddaby, 2006). Still, analytical procedures that find their routes in this method are considered useful when dealing with rich qualitative material (Turner, 1983). With time, two different schools of thought regarding the use of grounded theory developed, known as *the Straussian* (Strauss *et al.*, 1990) and *the Glaserian* (Glaser, 1992), but these did not affect the methodological approach in my study. In this thesis, open coding was conducted after key literature had been reviewed. As such, literature review at that stage served as a sensitizing device that would enable a better understanding of the data (Walsham, 1995). Thus, my analysis is thematic and cannot be labelled as grounded theory because of the stage in which the codes were informed by existing literature.

The third stage of thematic analysis involves collating the emerged codes to initial themes and discerning between codes and sub-codes. At this point, it becomes evident which themes can stand on their own, which have to be disregarded, and which themes should be combined together. Stages 4 and 5 represent an iterative process of the above, whereby the themes are named, refined and renamed based on the homogeneity of their content and their level of sense making. Finally, once this has been attained, thematic analysis allows the development of links between the emerged themes and current literature, while the narrative of the performed analysis is being written. Given that the team has been used as the unit of analysis across the three case studies, all themes that emerged from analysis are related to the team. For example, the findings from Study 1 are categorized as individual-, team-, and technology-related. It is later explained that though these findings relate to these three constructs, they are all viewed as pertaining to the team. In Study 2, which provides deeper insight on the unique characteristics of virtuality and their role for creativity, these are viewed as associated with the team as well.

Thematic analysis enabled me to relate my data to Objectives 2 and 3, namely elicitation of factors influencing VDT creativity (Objective 2), and elucidation of the relationship between creativity and virtuality (Objective 3). It was applied to: (a) the interview data; (b) the management issues identified in the videos (as explained in 5.5.1); and (c) written communication outputs (e.g. Skype IM). In Table 10 below I provide examples of the codes and sub-codes that emerged in the different datasets.

Table 10: Open and Axial Codes emerging from Thematic Analysis

Source	Open Codes	Axial Codes	Grouping
Interviews (Study 1)	Advising Pushing Educating Informing Challenging	Leadership	Team Level
Interviews (Study 2)	Technology unsuitability Technology failure Technology speed Technology artificiality	CMC	Virtuality
Observations (Study 3)	Login issues Reminder Sharing issue Updating Prezi	Managing virtually	Virtuality
	Reaching Geoff Overseeing progress Coordinating meeting Evaluating	Visibility	Virtuality
Written Communication Outputs (IM)	Unavailability Absence No response Unexpected	Boundaries, visibility and unavailability	Virtuality

Once analysis for each case study was completed, I synthesized the findings from each one and discerned the factors influencing creativity in the VDTs studied that are relevant in non-virtual (what I call traditional, physically collocated, or F2F team environments) from those relating to the unique characteristics of virtuality found in my studies (e.g. geographical dispersion). The two are discussed separately in Chapter 9, Discussion, where all findings are brought together. The former answer Objective 2 (discussed in 9.2.2) of my thesis and the latter Objective 3 (discussed in 9.2.3), enabling an improved understanding of the role played by the unique characteristics of virtuality.

Having discussed the data analysis methods, I turn to a description of the case studies, highlighting their suitability, the characteristics of the teams within each, and explaining the similarities and differences characterizing them.

5.6 The Three Case Studies: Similarities and Differences

In this section, I present the three case studies, focusing on their suitability as well as their similarities and differences. In so doing, I acknowledge that there are inconsistencies characterizing the three case studies, mainly owed to the opportunistic nature of my selection. In other words, considering the difficulty of access into a research setting, I capitalized on opportunities that were presented to me. Despite these inconsistencies, however, certain strategies—for example, the use of the same analytical approach for each case study, or emphasis on their similarities rather than their differences—acted as redeeming elements, helping me to generate credible conclusions. Below, I discuss the three case studies.

5.6.1 Brief Presentation of Case Study 1—the EGPR

Study 1 Project Description and Suitability

The first case study (henceforth Study 1) was conducted with the European Global Product Realization (EGPR) project. The study was conducted in an educational context and involved the investigation of six VDTs comprising students studying for an engineering-related degree (mechanical engineering and industrial design). The VDTs were multicultural, with four cultures present in each team, thus the Study 1 took a focus on Global Virtual Teams (GVTs). Consequently, heterogeneity was posited in all teams in terms of educational and cultural background, and, by extension, national and linguistic. The teams were inter-organizational, or inter-university more specifically, as students from different institutions were used to form each VDT. The project was hybrid in nature, combining a long virtual component and a short F2F one toward the end of the project. The degree of synchronicity of the Information and Communication Technologies (ICTs) the teams used was relatively low, involving predominantly asynchronous ICTs. Half of the teams were tasked with the design of a **toilet flushing system** and the other half with a **kitchen blender**. The EGPR ran for five months, thus was temporary in character, and the teams had no prior working history. As all participants were based in Europe, temporal dispersion was minimal. These issues are discussed in detail throughout 6.1 and 6.2.

As it follows, the EGPR was a suitable research site for this stage of this research. For example, the hybrid character of the VDTs overcomes a limitation that one sees in the literature when scholars take a focus on completely virtual or completely traditional (physically collocated) teams. Similarly, the participants in Study 1 are highly heterogeneous in several aspects. These issues are discussed in greater depth in 6.1.2.

Study 1 Research Approach and Outcomes

In terms of the research approach adopted for Study 1, this involved interviews (individual and in focus groups) with most participants at various times during the lifecycle of the EGPR. With interviews being the primary data collection method for this study, non-participant observation as well as reviewing several documents and design outputs contributed to a better understanding of the EGPR. Study 1 was an exploratory case study following an open, highly inductive approach. For example, no reference was made to such terms as *virtual*, or *virtuality*, or other themes emerging from the literature during the early stage interviews; rather these, and their role for creativity, emerged through discussion with the interviewees, and was done in my effort not be open to any themes that would emerge purely from the data. This was also supported by the open-ended questions the participants were asked (see examples in 5.4). Making minimal, if any, reference to issues emerging from the literature in the early stages of this study was done in an effort to let the data speak and contribute to the design of the remaining interviews at the later stages of the EGPR. Sections 6.3 and 6.4 provide a detailed description of the data collection and analysis processes respectively.

Analysis contributed an impression of creativity throughout the VDT lifecycle and unearthed a number of factors influencing creativity in the VDTs that were associated with three constructs: the individual, the team, and technology. Given that *the team* is used as the unit of analysis in this thesis throughout, the individual and technology in Study 1 were seen as characteristics of the team, or subunits of analysis; not as separate units. The analysis and findings of Study 1 are presented thoroughly in 6.5.

5.6.2 Brief Presentation of Case Study 2—ESTIA24

Study 2 Project Description and Suitability

The second case study (henceforth Study 2) was conducted in an educational context too, but with another project—ESTIA24 (as it will be referred to). ESTIA24 is a large project involving numerous teams; yet, Study 2 involved the investigation of a single VDT, with the aim of taking a closer look into some of the topics that emerged from Study 1 (e.g. relationship between creativity and virtuality). The VDT under investigation involved ten participants who formed two geographically dispersed subgroups (between the UK and France). Though heterogeneity was posited between the two subgroups in terms of such aspects as nationality, mother tongue, educational background (mechanical engineers vs. designers), the participants in each subgroup were highly homogeneous (with a few exceptions). Thus, heterogeneity was again high in Study 2, but to a lesser extent than in Study 1. The VDT was inter-organizational again, between two institutions. Though this was again a GVT, drawing on participants from different countries, this was a Partially-Distributed Team (PDT). Study 2, therefore, involved the investigation of different type of VDT to the ones involved in Study 1. There exist other differences too. For example, the project was highly virtual, as the two subgroups did not have a chance to meet F2F. The degree of synchronicity of the VDT was mostly high, as the participants made use of predominantly synchronous ICTs for communication and collaboration between the two subgroups. However, communication and collaboration within each subgroup was F2F. The team was tasked with the design of an **eco-friendly recycling reminder** for the office. ESTIA24 ran for a constant 24 hours with no breaks, thus was temporary in character, and the VDT had no prior working experience. Temporal dispersion was insignificant (one hour difference between the UK and France). These issues are thoroughly explained in 7.1 and 7.2.

ESTIA24 was a suitable research site for this stage of the research for a number of reasons. This case study presented me with a significant advantage of capturing most of the team's interactions and activity, due to the very short (24h-long) duration of the project. Admittedly, this would have not been possible in any other research setting presented to me. What is more, Study 2 comprised students,

similarly to Study 1, but the pedagogical aspect when looking into student participants was much absent, as ESTIA24 was an extra-curricular activity—not one that counted toward anyone’s degree. Lastly, Study 2 drew on a particular type of a VDT, a PDT, thereby extending the contribution of previous findings. The suitability of Study 2 is outlined further in 7.1.2.

Study 2 Research Approach and Outcomes

The research approach for Study 2 built on that of Study 1 in order to overcome some of the limitations of Study 1. Interviews again constituted a main data collection method, as also did observations of the design process and analysis of the communications between the two subgroups as well as analysis of the design outputs. On the one hand, interviews were again semi-structured, involving open-ended questions; however, they were more focused and, further to aiming to gather the interviewees’ perceptions around creativity and virtuality in the VDT context in which the study took place, they aimed at unravelling and elucidating the role of virtuality. Thus, though the approach was still inductive, the literature on this topic was also considered in the analysis of the interview, and other, data in this study. Thus, one of the contributions of Study 2 is the improved understanding of the relationship between creativity and the unique characteristics of virtuality. Further, the observations (facilitated by the recordings of the VDT design process) provided a better picture about several management issues that were found to influence creativity in Study 2. Lastly, though the study was qualitative, the ideas’ count and naming of the design ideas the VDT generated throughout the VDT lifecycle enabled me to provide a better illustration of the relationship between creativity, the VDT lifecycle and the design process. Analysis and findings of Study 2 are presented in 7.5.

5.6.3 Brief Presentation of Case Study 3—A Comparative Case Study in Industry

Study 3 Project Description and Suitability

Study 3 was a comparative case study that was pursued in an industrial VDT context. It took the case of a single design team that conducted two design projects for different clients. Thus, the key difference between Study 3 and the previous two case studies is that Study 3 used an industrial VDT context, whereas Studies 1 and 2 an educational. However, as it is common in industrial contexts, one team member became unavailable due to other organizational priorities and therefore much of the project work was accomplished by two members only. The first project of Study 3 (the design of a body lifting mechanism for boats) was conducted in a F2F environment, wherein all participants were physically collocated. The second project (the design of a window glazing system) was conducted by the same participants being geographically isolated, thus working as a completely virtual design team. Thus, the study has two components: a F2F and a virtual. As opposed to the previous two studies, Study 3 was highly monocultural, as all participants were UK nationals. Furthermore, they all had similar educational background. Therefore, the team in Study 3 was highly homogeneous. What is more, this was an intra-organizational team, as all members were affiliated with the same organization. The degree of synchronicity characterizing communication and collaboration of the VDT (virtual component) was mostly high. In addition, while the participants had no working history prior to the F2F component of the study, they had evidently worked together when the virtual component commenced. Both projects were temporary in character, and also highly comparable, lasting two working weeks each. Full discussion around these matters is presented in 8.1 and 8.2.

The research site in which Study 3 was pursued—a local design practice which I call Alpha—was a suitable one because it was an organizational context, enabling this research to go a step further by allowing it to produce findings that could be of value to practitioners. Further, Alpha showed flexibility around the manner in which the

two projects would be realized, so that they enabled comparison between a virtual and a F2F design team. Section 8.2.1 outlines Alpha's suitability in more depth.

Study 3 Research Approach and Outcomes

The methodological approach for Study 3 was highly similar to the one adopted for Study 2. It involved interviews with the participants (twice, at the end of each component) and also observations (F2F and through recordings) and review of the design and other communication and collaboration team outputs. Importantly, the research approach adopted here added to the contribution of this thesis by (a) investigating the industrial context; and by (b) enabling comparison between virtual and F2F design teams, through the way the study was set up. Analysis was still inductive, yet the literature on virtuality was taken into account in analysing the data of Study 3. Analysis and findings are presented in full in 8.5.

The above discussion presented the three case studies and outlined (a) the team characteristics; (b) the research sites' suitability for the specific stages of the research in which each case study was conducted; and (c) the reasons behind the research approach espoused for each cases study. As it follows, there exist both similarities and also differences between the case studies, which have been briefly explained and will be elaborated further in the respective chapters. These—along with the rest of the characteristics discussed earlier—are summarized in Table 11 below for better presentation.

Table 11: The Main Characteristics of the Three Case Studies

		Study 1	Study 2	Study 3	
				F2F	VDT
Differences	Context	Educational	Educational	Industrial	
	Geographical Dispersion	Global (European, 4 countries)	Global (European, 2 countries)	N/A*	National (1 country)
	Diversity	Multi-cultural (4 cultures per team)	Multi-cultural (3 cultures)	Mono-cultural (1 culture)	
	Relation to Organization	Inter-organizational	Inter-organizational	Intra-organizational	
	Degree of Virtuality	Hybrid	Virtual (between 2 subgroups)	F2F	Virtual (all isolated)
	Working History	N**	N	N	Y
	Design Task	Toilet flushing system or kitchen blender	Eco-friendly recycling reminder for the office	Body lifting mechanism for boats	Window glazing system
Similarities	Level of Continuity	Temporary (5 months)	Temporary (24 hours)	Temporary (2 weeks)	Temporary (2 weeks)
	Temporal Dispersion	Minimal	Minimal	N/A	N
	ICTs used	Asynchronous/ Synchronous	Asynchronous/ Synchronous	N/A	Asynchronous/ Synchronous
	Members' Familiarity	Medium/High (e.g. through F2F work)	Medium/High (i.e. within subgroups)	N/A	Medium/High (i.e. prior F2F work)
	Task	Design-oriented	Design-oriented	Design-oriented	
	Unit of Analysis	Team	Team	Team	
	Focus of Analysis	Participants' Perceptions VDT Outputs (i.e. team presentations)	Participants' Perceptions Intra-team Interactions VDT Outputs (e.g. sketches)	Participants' Perceptions Intra-team Interactions VDT Outputs (e.g. written communication)	

* N/A = not applicable, ** N = no, Y = yes

5.8 Onward

In this chapter, I have presented the research approach that was espoused to address the RQ of the thesis. With an interpretive stance, a qualitative methodology, and a case study approach, I also outlined the data collection and analysis methods I employed, and provided an overall description of the three case studies, their role in answering the RQ, the characteristics of the VDTs in each, and the suitability of each research site. Presented next (in Chapters 6-8) are the three case studies I pursued with the aim of addressing the RQ.

Chapter 6: Case Study 1—the EGPR

In this chapter, I present an exploratory case study I pursued in my quest to (a) start exploring creativity within the Virtual Design Team (VDT) lifecycle; (b) elicit factors influencing creativity in this context; and (c) pave the way for the remainder of this thesis. In what follows, I present the research site and explain its suitability for my research at this early stage, introduce the teams under investigation, discuss the data collection and analysis processes, and present the findings that emerged from my analysis. I close the chapter by reflecting on the case study and outlining the steps onward.

6.1 Research Site: The EGPR

The European Global Product Realization (EGPR) project was founded and first run during the academic year 2001/2002 by Professor Imre Horváth at Delft University of Technology, the Netherlands. Developing the right partnerships between companies and universities, where partners should have their counterparts' missing resources at their disposal, is central to the EGPR (Zavbi *et al.*, 2009). This is in line with research that highlights the creative potential benefits of bringing diverse people together (Elias *et al.*, 2011).

Drawing on the design education literature, Horvath *et al.* (2003) detect three generations of unconventional educational approaches: the first draws on the concept of the virtual university—where students are exposed to international classmates and wide diversity—while the second generation introduces the virtual enterprise and project. The EGPR situates itself within the third-generation of unconventional educational approaches, one which incorporates the use of advanced Information and Communication Technologies (ICTs) in the classroom and has a quadruple character and role to play: technological, pedagogical, contextual, and social (Figure 16).

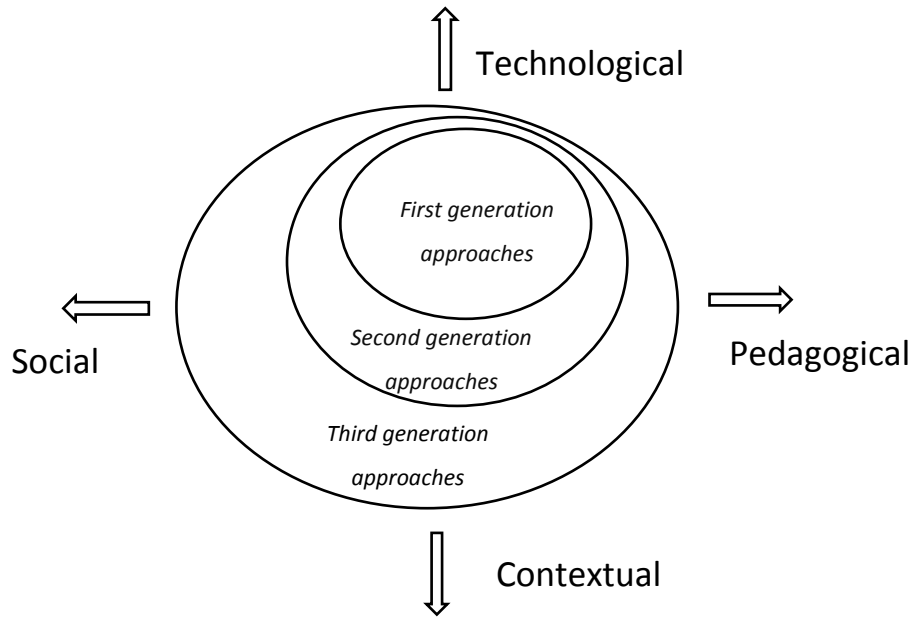


Figure 16: The Scope of the EGPR (after Horvath *et al.*, 2003, p. 85)

Since its inception, the EGPR has brought together students from different European Universities in order to accomplish the objectives outlined in Figure 16. Per its website and other research, the EGPR is described as “a Video-Conference (VC)-based engineering course” (Zavbi *et al.*, 2007, p. 50), or “an international academic virtual enterprise” (Chan *et al.*, 2006, p. 2). This innovative set-up allows its participants to expose themselves to real-life projects and, as such, to be better prepared for their first job appointments, while the industrial partners are also present to supply the working materials, give feedback, and capitalize on the students’ creative ideas, thus implementing educational and research objectives. That aside, the EGPR participants conduct navigated active learning, perform operational research in design, do real life industrial design, and develop hybrid prototyping of global products (Figure 17).

The aims of the EGPR are explicit to coaches and students. As the organizers themselves put it,

“When we initiated EGPR, the idea was that students graduated from university with no real work experience; with the EGPR, we have overcome the limitation that students don't have work experience when they graduate.” (observation extract, phase 4)

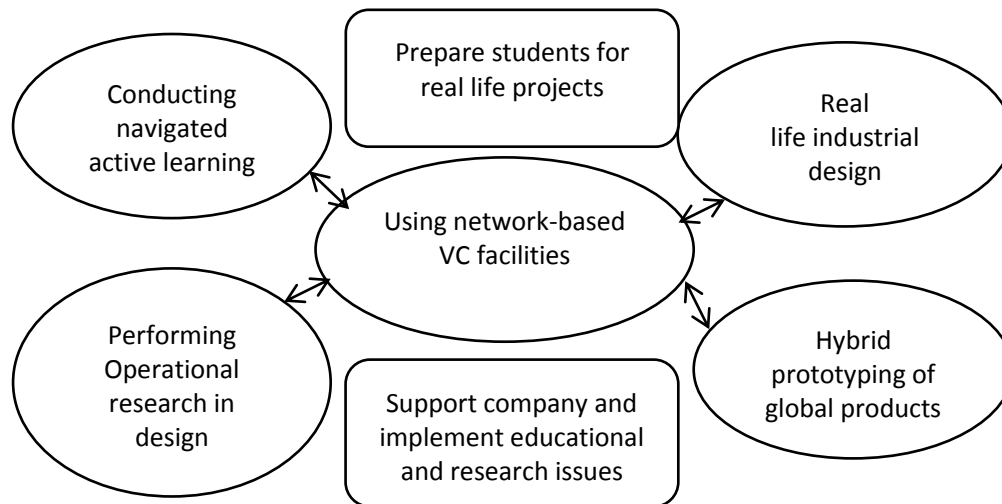


Figure 17: Main Aims of EGPR (Kovacevic, 2008, p. 1384)

Further, the organizers underline that:

“The EGPR is all about teamwork [...] it shows that different nations can work together and produce very high quality work [...] friendships and long-term collaborations develop ...” (observation extract, phase 4)

By this, they also highlight its social aspect (Figure 16). To this end, the EGPR aims to assist students in developing design competence, which the organizers see as constituted by capability, attitude, knowledge, skill, and experience (Horvath, 2006). Another unique feature of the EGPR is the high degree of creativity involved in the design tasks; not only in the prototypes to be produced, but also in the design process the participating teams are expected to follow.

Due to its innovative set-up, the EGPR has attracted much academic interest by several researchers, mainly individuals who are involved in its organization themselves. Their studies have yielded findings which: (a) gauged the pedagogical impact the EGPR has on the students (Horvath *et al.*, 2003; Zavbi *et al.*, 2007); (b) investigated virtual communication patterns (Chan *et al.*, 2006; Tavcar *et al.*, 2005); (c) investigated design competence development (Horvath, 2006; Kovacevic, 2008); and (d) looked at the students’ reflections (Zavbi *et al.*, 2009). These studies are important, but have aimed to improve the quality of the EGPR and not to advance our understanding of creativity in the virtual environment of the EGPR. Some of

these studies have looked at creativity, but the researchers have used quantitative methods to measure it, such as questionnaires. As it follows, these studies have neglected the relationship between virtuality and creativity in the EGPR, and their emphasis is placed elsewhere.

The EGPR participants collaborate predominantly virtually for a period of five months (February-June) during the spring semester, aiming to design, assemble, and present a prototype. All participants are given access to a number of communication media (outlined below) and are required to attend a number of lectures held virtually. These virtual lectures aim to educate the students on how to collaborate and design virtually; they are therefore important, as most students have limited—if any—experience of designing virtually. During the academic year 2009/2010, four European Universities from the following countries partook in the EGPR (alphabetically): Croatia, Hungary, Slovenia, and the UK (Figure 18).

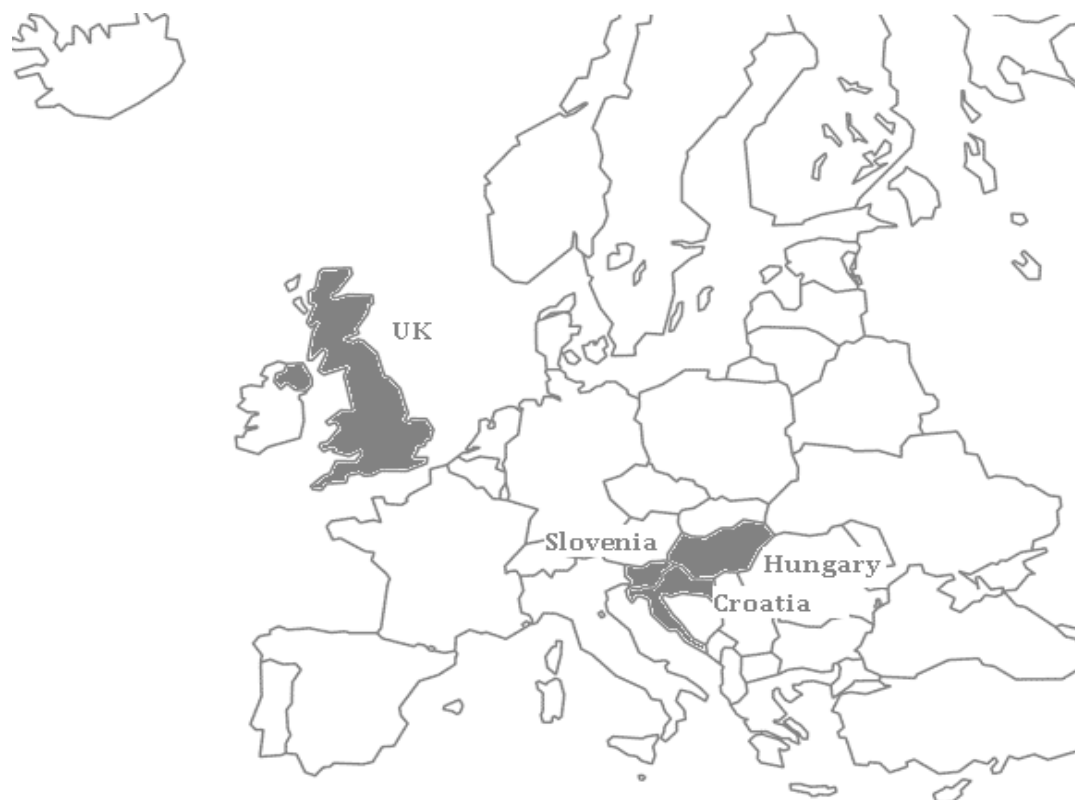


Figure 18: The EGPR Map for the Academic Year 2009/2010

6.1.1 The EGPR Organization

Though there are variations with regard to the participating universities each year, one university assumes a leadership position, hosts Phase 4 of the project, and defines who the industrial partner(s) will be. One or two industrial partner(s) each year decide on the product, give students feedback, and provide them with the materials. The product development process is broken down to four predefined phases. Phases 1-3 are held exclusively virtually—with the students based in different locations and with them not having met one another Face-to-Face (F2F)—whilst in Phase 4 students get together in a traditional, F2F environment to assemble their prototypes and give the final presentation on them. The structure of Phase 4 is shown in Figure 19, as extracted from one of the documents that were reviewed. Therefore, the EGPR is hybrid in character, comprising both virtual and F2F components.

FINAL WORKSHOP PROGRAM

Brief Outline

Monday will begin with a tour of Faculty of Mechanical Engineering Ljubljana. After you will get acquainted with the Faculty, you will split up into your groups and begin work. We have allocated computer rooms and workshops for your use.

You have time to work Monday, Tuesday afternoon, Wednesday and Thursday morning. On Tuesday morning we will take the time to visit both of the companies participating in this year's EGPR. Thursday afternoon is reserved for testing and finalizing the prototypes. Friday is set-aside for your presentations and the Exhibitions of your Prototypes. The two important deadlines are:

1. Poster Deadline: Wednesday at 14:00 CET, a maximum of two per group.
2. Presentation Deadline: Thursday 17:00 CET.

Submissions should be made electronically by placing the Posters and Presentations on FTP server and Huddle in the correct Folder.

At the end of each day, at 17:30, there will be a team meeting to discuss any problems and evaluate the progress.

On the next page you can find detailed schedule of the workshop week.

Figure 19: Phase 4 Structure and Guidelines (document extract)

The design process is monitored by the industrial partners at the project reviews, upon completion of each phase. At the end of each phase, the students have to complete a report for their assessment and have the chance to receive industrial feedback and proceed to the next phase. The phases are presented in Table 12 below. Following this, I proceed to discuss the EGPR's suitability.

Table 12: The EGPR Phases

	Phase	Environment	Objective
Phase 1	Market Research	Virtual	Market Research and Design Problem Definition
Phase 2	Conceptual Design	Virtual	Functional Requirements and Morphological Charts Development
Phase 3	Design Finalization	Virtual	Detailed Computer-Aided Design (CAD) Models of Selected Products
Phase 4	Final Workshop	F2F	Prototype Assembling and Presentation

6.1.2 The EGPR Suitability

The EGPR proves to be a pertinent research site for the following reasons:

It is meant to incite creativity to the students, while its history demonstrates that VDTs not only do not always fail, but they manage to achieve their targets and produce creative outputs, refuting previous research arguing otherwise (Monalisa *et al.*, 2008).

It deploys hybrid teams that comprise virtual and F2F components; in other words, this is a different configuration to the one investigated in previous VT literature (e.g. Ocker, 2005). This Virtual Team (VT) configuration offers several benefits: (a) it overcomes the limitation that emerges from the traditional comparison between F2F and VTs in the literature (Kerr and Murthy, 2004; Webster and Wong, 2008) by taking the case of VDTs which operate partially virtually and partially F2F; (b) is consistent with recent conceptualizations of VTs that speak of virtuality in teams, rather than VTs *per se* (Dixon and Panteli, 2010; Griffith *et al.*, 2003); and (c) it is closer to industrial reality.

The participating VDTs are globally dispersed and comprise a heterogeneous student body in terms of country of origin, culture, and education, among others. Also, the participants are not limited to the use of asynchronous media, but also use synchronous facilities (e.g. VC) and other tools of their choice. What is more, the EGPR offers the opportunity for research into real teams, not dyads. These three elements extend previous research on VT creativity which focused on either virtual collaborations in dyads (Martins and Shalley, 2011), or VTs that were mono-cultural and limited to the use of asynchronous media for collaboration (Chang, 2011; Ocker, 2005).

Presented next are the teams under investigation.

6.2 The VDTs under Investigation

A large number of participants from the four European Universities involved in the EGPR partook in the interviews. Six teams were formed, of which five comprised seven students and the remaining one comprised eight students. Physically collocated subgroups existed in all teams; specifically, each team would have 3 or 4 participants from Slovenia, 2 participants from Hungary, 1 or 2 participants from Croatia, and 0 or 1 participant from the UK. In addition to the students, a supervisor, called *the coach* was assigned to each team. Either a faculty member or an EGPR alumnus/a, the coach was accountable for the teams' presence in the VC meetings, directing and advising their team, answering questions, and ensuring their team was on track. Half of the teams were tasked with designing a toilet flushing system and the other half with a kitchen blender. Below I discuss the team characteristics, namely the participants, the methods of communication, and the level of subgrouping in team formation.

6.2.1 The EGPR Participants

The EGPR participants—students and coaches—varied in many aspects: nationality, gender, mother tongue, level of English, education, age, and others. All students from all institutions involved partake voluntarily—the EGPR is not a required module for their degrees. Each institution announces the EGPR at the start of each academic year and a certain number of students who have expressed interest in it are selected by the EGPR organizers. The students were all nationals of the country in which they studied, barring the four students from the UK, who were not UK nationals (1 European, 3 non-Europeans). Hence, the mother tongues spoken by each individual were (alphabetically): Croatian, Hindi, Hungarian, Persian, Slovenian, and Spanish. English—the EGPR working language—was therefore a second language for all participants. A high proportion of the participants were male, and typically, each team would only have one or two female participants. With respect to the students' education, the EGPR drew from mechanical engineers (Croatia, Slovenia, UK), and industrial designers (Hungary, Slovenia). All teams were relatively homogeneous in terms of age. Of the six coaches, half were faculty members and the other half EGPR alumni from a previous year. Again, English was a second language for all coaches

too, while the most significant differentiator among them was the country of origin, and the level of experience.

6.2.2 Methods of Communication

The teams conducted two VC meetings per academic week (excluding holidays). In Figure 20 below a picture from a VC lecture from a previous year in the EGPR is provided, in which I show how the students collaborated using a VC system. VC constituted the only synchronous method of communication provided by the EGPR. Furthermore, students were given access to an FTP-server and to Huddle, an online tool for managing people, projects, and business information securely. These tools allowed them to save files at any time from different locations and proved useful for exchanging drawings and being able to rotate the workload. Barring these and their university emails, participants were given the freedom to select among other, personal ICTs, such as Skype. The latter was used both synchronously (as a form of VC) and asynchronously (through Instant Messaging (IM)), but mainly within certain subgroups within each team (e.g. two individuals working together) and not by entire teams. While in Phases 1-3 communication was accomplished exclusively via ICTs (the ones outlined above), Phase 4 was held in a F2F environment.



Figure 20: VC Lecture from a Previous Year (document extract)

6.2.3 Subgrouping in Team Formation

Though the EGPR organizers aimed for maximum dispersion in order to simulate a truly global project (i.e. each VDT member would have been isolated), physically collocated members existed in all teams, particularly in Slovenia. This was owed to the unequal number of students that partook in the EGPR, and it arguably lessened the degree of geographical dispersion and virtuality in some teams, and influenced the dynamics within them, as the physically collocated subgroups of each team could collaborate in a traditional, F2F environment during the project.

6.3 Data Collection Process

My data collection involved interviews, non-participant observation, and document review (see detailed data collection steps in Figure 21). For this study, interviews constituted the main data collection method, as non-participant observation and document review were only used for familiarization purposes, and to develop a better understanding of the EGPR, its processes, and the design context. I conducted interviews with most participants individually and in focus groups; and both F2F and remotely over Skype. The interviews ranged from 20 to 60 minutes each. Consent for audio recording was given by all interviewed, while it was also agreed that the data would be used for research purposes only and sensitive information would not be disclosed. The relevant approvals and akin agreements can be seen in Appendices A and B.

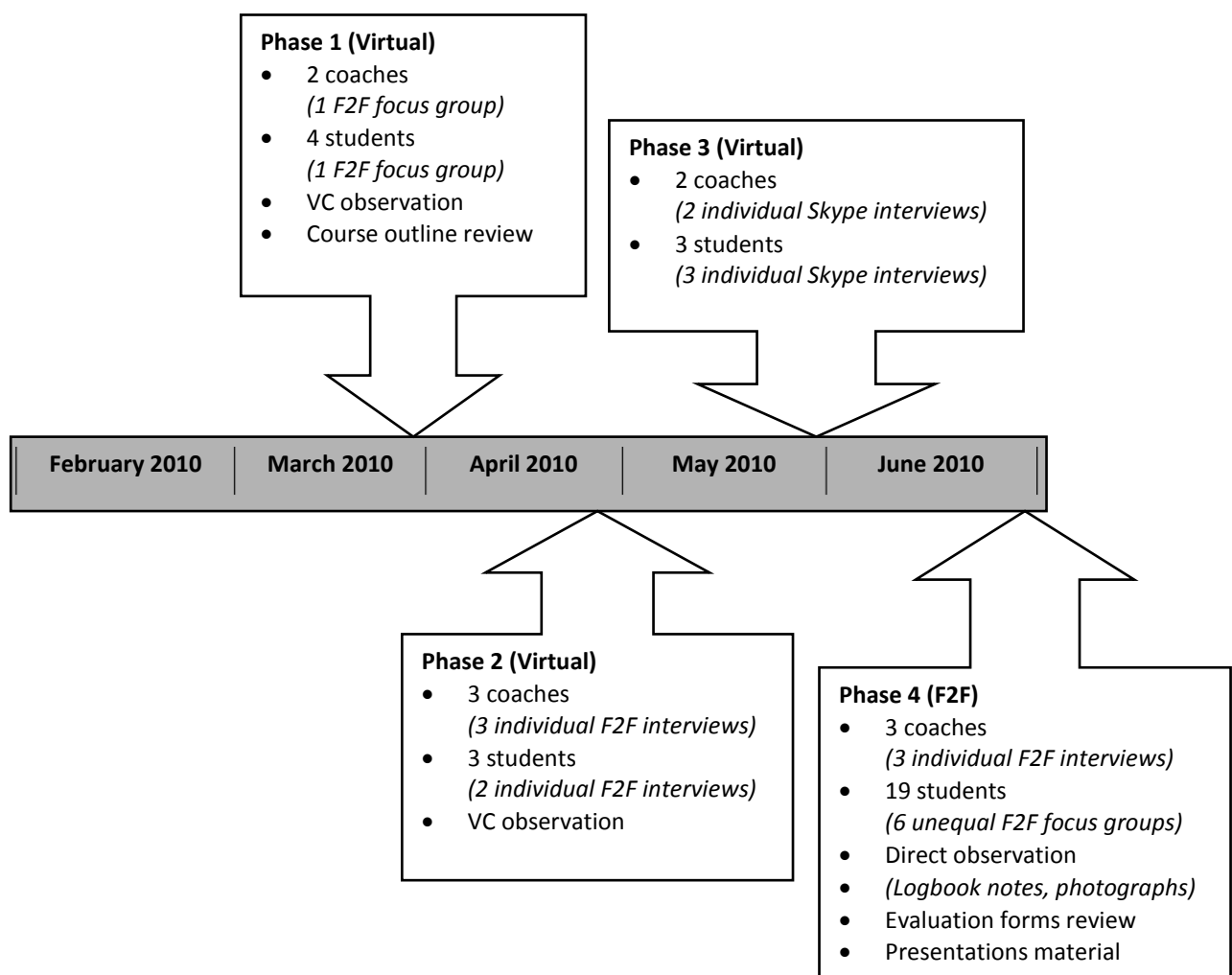


Figure 21: Detailed Data Collection Steps

Initially, I conducted two 45-minute-long focus group interviews in the UK site once Phase 1 had been completed. Therefore, my involvement in the EGPR did not start until the end of Phase 1. The participants in these focus group interviews, coaches and students, were all members of different teams. In these semi-structured focus group interviews, the participants were asked to reflect on their experience of being VDT members (e.g. the design process, their motivation, the virtual aspect); therefore, my open-ended questions did not make reference to creativity at that stage. Instead, I gathered background information that helped me understand the context in which they worked. The themes that emerged from these interviews were later used in the design of the follow-up interviews—and other interviews with participants that had not been previously interviewed—in Phases 2-4. In these phases, most interviews lasted around 20 minutes each and the interviewees were asked explicitly about creativity and the circumstances under which ideas were generated—either by individuals or within a team situation.

The interview data gathered during Phases 1-4 are significant because they offered useful accounts regarding creativity and virtuality as the project evolved, capturing the VDT lifecycle nearly from the start through to the end of the EGPR. However, the biggest part of the data were collected during the last two days of Phase 4, when the participants had already completed their designs and assembled their prototypes; at that time, the participants were also able to compare the virtual with the F2F phases, although memory biases might have hindered their ability to recall examples from earlier phases. During Phase 4, one focus group interview was conducted with each team (coaches were interviewed separately), which lasted around 45 minutes; the number of interviewees varied from 3 (in one team only) to 5 (see Table 13 later). Having all members participating in the focus group interviews was not achieved due to time constraints, different project priorities and some participants' unavailability. Finally, individual interviews with some of the coaches were also carried out and these lasted from 20 to 60 minutes (one via Skype upon completion of Phase 4). The content of the questions asked at the later interviews originated from the data collected in Phases 1-3. In the last interviews, the data reached

saturation, and I felt that all the factors perceived by the participants to be influencing creativity in their VDTs had been elicited.

Non-participant observation and document review were used as complementary data collection methods. I attended a one-hour VC session on the same day when the initial focus group interviews were conducted, from the project's site in the UK (Phase 1). I also attended another VC session from Croatia (Phase 2), as I happened to be there for a different purpose. It was then when the students presented their second review reports on their outputs. I also conducted observations during the two final days of the workshop. Non-participant observation at that last stage involved: (a) watching the teams assembling their prototypes; (b) watching them facing and resolving problems; (c) watching them preparing their posters and attending their presentation; (d) being present at their assessment given to the faculty; and (e) attending the final coach meeting. Hand-written notes from the observations were taken and kept in a logbook. Document review consisted in reviewing: (a) documents from the current and previous academic years regarding the EGPR; (b) guidelines and instructions documents given to the students; (c) the course outline (at the beginning of the EGPR); (d) the final team- and individual-specific evaluation forms used by the industrial partners (at the end of the EGPR); and (e) team presentations at the end of Phase 4. These complementary data collection methods are also included in Figure 21.

6.4 Data Analysis Process

The interviews were listened to twice and were transcribed manually. I did not follow a line-by-line fashion or classified the interview data per interviewee. This would have resulted in an overabundance of codes that would not add much value; plus it would have added unnecessary difficulty due to the different voices heard in the focus group interviews. Once all interviews were transcribed, I inserted the raw data into QSR NVivo 9 and performed thematic analysis. Initially, I performed open coding based on themes that emerged recurrently in the narratives. At that stage, I remained open to identify new themes and ideas that emerged purely from the narratives, without considering relevant literature. NVivo proved useful in helping to organize and group large interview extracts per code.

Using the emerged open codes as a datum, I proceeded to axial coding, borrowing existing themes from the virtuality literature to name the factors whose relationship with creativity has not been previously investigated. For instance, an open code about two participants that were physically collocated during the virtual phases of the EGPR, initially coded as Physically collocated members, was later grouped under the axial code Subgrouping—borrowed from the VT literature. NVivo at that stage helped me gauge the frequency in which the identified themes came up, and classify them to major/minor. Further to the number of times each theme appeared (e.g. 44 data points made reference to individual factors influencing creativity), I also took into account the tone of voice the interviewees expressed themselves with. For example, some participants felt the need to express their disappointment to me about the fact that their ideas were not heard due to prevalence of ideas generated by others within their VDT. I also identified the role played by each factor and classified them to creativity enhancers and inhibitors. Lastly, I associated the emerged factors with three of the constructs—also featuring in my theoretical framework (Chapter 4, Figure 13)—which were used as a skeleton at the time I was analysing these data: the individual, the team, and technology. What is more, some of the emerged factors were found to be associated with the organizational level of creativity, which is also mentioned in my theoretical framework. However, given that

the EGPR is an educational setting—and therefore lacks the dynamics found in an organization—these factors may not be of industrial significance.

In addition to the interview data, I also used my notes and photographic data I gathered from my observations to enrich my understanding of the project, especially during the early phases of the EGPR, but also during Phase 4, when the teams got to work F2F in Slovenia. However, most photographic data I gathered cannot be used in my thesis due to confidentiality agreement I signed with the EGPR (Appendix B). I also reviewed a number of documents, including descriptions of, and guidelines for, the EGPR from the current (2009-2010) and previous academic years. The documents were helpful in a number of ways during the data analysis process. For example, they helped me develop an understanding of the participants' backgrounds, the structure of the EGPR and the different purposes for the different phases, the industrial partners' assessment criteria on completion of each phase, and the design outputs as they were being presented to the industrial partners and faculty at the very end of the EGPR in Slovenia. In order to protect the anonymity of the participants and the industrial partners, I have blurred their faces on the limited photographic data included 6.5—Analysis and Findings).

6.5 Analysis and Findings

I begin this section by presenting the six teams (Table 13) and by showing pictorially that creativity was not equally high throughout the VDT lifecycle (Figure 22). The last part of this section centres on an analysis of the factors that were found to influence creativity in the VDTs under study.

6.5.1 Presentation of the teams

Table 13: Presentation of Teams and Interview Data Collected

	Product	Team Participants	Phases 1-3 Interviewees	Phase 4 Interviewees
Team 1	Kitchen blender	8	1x3	4
Team 2	Kitchen blender	9	1x2	5
Team 3	Kitchen blender	8	1x2 & 1x3	3
Team 4	Toilet flushing system	8	1x1	3
Team 5	Toilet flushing system	8	1x2	3
Team 6	Toilet flushing system	8	2x2	4
6 teams	6 prototypes	49 participants	17 individual interviews	22 interviewees individually or in focus groups

Table 13 summarizes the six teams that partook in the EGPR, along with the product they had to design and develop, and the number of the individuals that (a) comprised the teams (participants) and (b) the ones that were interviewed (interviewees) per project phase. The table also highlights that not all the teams were engaged in the design and development of the same product, nor similar numbers partook in the (individual and/or focus group) interviews conducted. It nevertheless shows that all teams comprised seven members, with the exception of

team 2. The numbers include the coach of each team and in the *Phase 1-3 Interviewees* column the x stands for the number of times each individual was interviewed which resulted in thirty-nine interview extracts (e.g. in Phases 1-3, 1x3 means that one participant was interviewed three times). It follows also from Table 13 that while the project comprised 49 participants, I conducted 17 individual interviews and 22 participants were involved in the focus group interviews, resulting in 39 interview extracts in total.

6.5.2 Creativity Fluctuation during the EGPR Design Process and VDT Lifecycle

One of the aims of this thesis has been to understand creativity throughout the VDT lifecycle (Objective 1). My observations and discussions with the participants during my semester-long data collection experience highlight that creativity was not always high or necessary throughout the VDT lifecycle:

*“... when you do the functional requirements [...] **you have to go by the book and there is no space for creativity.**”* (coach, phase 2)

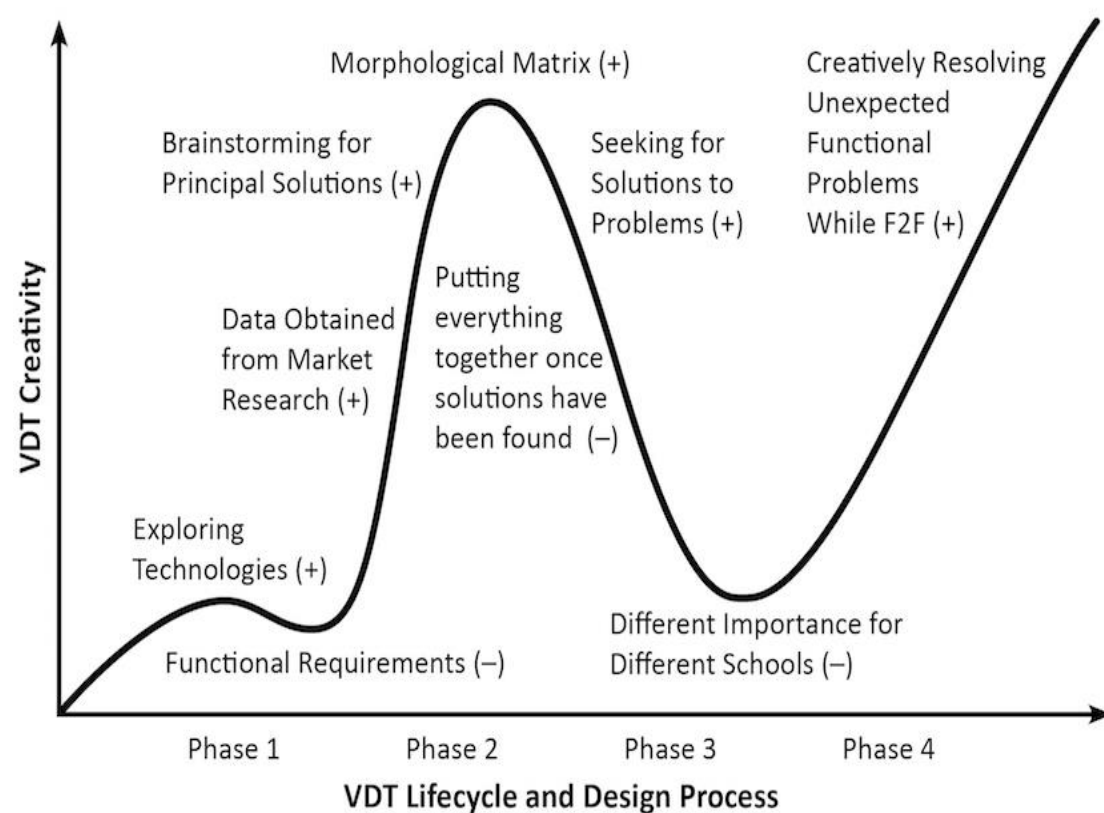


Figure 22: Creativity in the EGPR Lifecycle

In view of Objective 1, and in order to show how creativity fluctuated throughout the VDT lifecycle, I developed Figure 22 above, drawing on my interpretations of what the information I gathered from the EGPR participants. Figure 22 does not imply an attempt to quantify creativity, but it rather constitutes an effort to illustrate my interpretation of the fluctuant character of creativity during the EGPR. The horizontal axis represents the VDT lifecycle broken down to the four phases of the design process that were predefined by the EGPR organizers, while the vertical axis

shows the degree of creativity (as idea generation). Issues that were found to influence VDT creativity positively appear above the drawn line and are succeeded by (+), and those found to influence VDT creativity negatively appear under the drawn line and are succeeded by (-).

The story from one of the coaches that follows gives one example of how teams generally performed from start to end. Such stories were used to draw up Figure 22.

“Teams went there from different ways. Some combined immediately all their ideas together and went straight to the principle solutions, whereas some others said ok right, we're not satisfied enough, we want more. These went for more brainstorming sessions and went through some crazy ideas, e.g. every time I press my blender's button I want it to go live on Facebook and things like that. After that they had to find innovative ways to put it all together; here you shouldn't be too creative but rather down to earth and imagine how it is going to work. I guess there is no room for creativity here, but then you have to identify the weak points and be creative to overcome them. We are now at the point that we are going to face many problems and be creative to seek solutions, let's say 'I can make this but it might weigh 20 kilograms, which is not good'. After that point there will again be no room for creativity, after the problems are solved.” (coach, phase 2)

Initially, the students seemed enthusiastic about their involvement in the EGPR and showed some creativity while doing market research and exploring the technologies they would use for their communication with their virtual teammates. That was the point where the participants started to develop an understanding of what was expected of them and what the process they would undergo would look like. It is also worth noting that it is then, namely at the start of Phase 1, when students got acquainted to one another using ICTs. Creativity subsequently dropped by the end of Phase 1 when the teams had to concentrate on developing the functional requirements for their designs. As many argued, this was a stage where they all had to go by the book. However, Phase 1 was the starting point for their creativity; it enabled the students to identify consumer needs, or gaps on the market, which in turn gave rise to the generation of new ideas:

“In the first phase we did a survey which showed that a lot of people would prefer to pay extra money for an environmentally friendly product. So we decided to design a whole new system. We took this decision because in 50 years the flushing system had not changed at all, there had to be done something about it.” (student, phase 4)

Phase 2—the conceptual design phase—was one where creativity peaked. Phase 2 was meant to incite creativity, as students had to brainstorm and generate as many ideas as possible in order to develop their morphological matrix. The ideas that were generated by the teams during Phase 2 were the product of individual as well as of team creativity:

“In the second phase there were lots of ideas which were just random both by an individual and by the whole team. So, some ideas came from one single person and then they were discussed among the group, whereas other ideas came from group brainstorming.” (coach, phase 4)

The instructions given to the students regarding Phase 2 were aimed to enhance their creativity:

“When the innumerable ideas have been created for the principle solutions, take a good rest before proceeding to the next activity. Back at work, take one of the pieces of paper with the ideas for a principle solution, and start thinking of a solution that is based on these idea sketches. For this process I cannot actually give a guideline: follow your intuition, your drive for innovation, your longing for designing new unexpected results, and your longing to proudly present the resulting concepts to the company. The joy of designing is what matters.

However, the further you come in the elaboration of a principle solution into a useful concept, the more important it is to consider the technical feasibility of the solution. You will end up with a concept that is based on the selected principle solution, that is feasible, that is attractive, etc. In this phase not all technical details will be solved, but you must be sure that they CAN BE solved.

This you will do for each of (for instance) six to eight principle solutions, resulting in an equal number of concepts that are really different. Now it is important that every elaborated concept is viable, that it can be selected as a promising concept, that all of them fulfil the functional requirements to some degree. Remember that a concept will be candidate for the selection procedure that it could be chosen to be the final concept. Therefore you must take care not to develop concepts that does not compare with the other concepts (regarding quality and viability)." (document extract)

The students collaborated using a set of ICTs that were both chosen by the EGPR organizers (i.e. VC) and by the students themselves (e.g. Skype) and generated ideas that were considered highly creative, both by the coaches and by the industrial partners:

"I was quite impressed with their creativity. Creativity has been very good, for example the team I am coaching were thinking a flushing system by having sensors, which is very good because there is not anything similar on the market. Even the company admitted that, it's something really new, which has to do with the environment, they thought about have disinfectant being injected into the system to deodorize the whole system." (coach, phase 2)

Creativity remained high during the early stages of Phase 3, as students sought to find solutions to problems that emerged while trying to put their ideas together. Towards the end of Phase 3, however, creativity decreased. That was a stage where, as many asserted, there was no room for creativity; students had to go by the book and develop their designs. Adding to this, at that point, some of the students had other academic engagements that did not allow them to engage as much as they wanted in the EGPR. Still, Phase 4—the F2F workshop in Slovenia—enjoyed high degrees of creativity; students faced a number of unexpected problems while developing their prototypes in a F2F environment and, as they explained, they had to come up with quick and creative solutions. In Figure 23 I show how the teams worked together during the F2F workshop, implementing their ideas. As a student put it,

“We were having buttons for the handle, they were supposed to stick out of the handle, but the handle was too thick and the button not big enough, so they were like inside the handle, they didn't stick out. The guy from London, [Michael], and I were thinking what to do and we saw the eraser (pencil eraser) and we used this material for button.” (student, phase 4)



Figure 23: Teams working F2F during Phase 4 (photographic data)

It follows from the above analysis that the nature of the tasks as well as the predefined design process the teams underwent acted as determinants of creativity. While, for example, during Phase 1 the students tried to get to know each other and develop trust while working towards their initial task (market research), in Phase 3

they were challenged with the task to maximize their ideas and get down to the best ones by the end of the phase. Hence, room for creativity in Phase 1 was limited, whereas in Phase 2 creativity increased dramatically.

The chapter continues with examples of high creativity the participants shared with me during the interviews.

6.5.3 Examples of High Creativity in the EGPR

In this section, I provide examples of high creativity the participants shared with me, in order to illustrate how high creativity was perceived by the participants—students and coaches—and also by the industrial partners and academic faculty involved in the EGPR. Though photographic evidence was gathered that could support the discussion that follows, this cannot be included in the thesis due to the confidentiality agreement I signed with the EGPR.

Creativity in the EGPR took many forms. For example, some creativity was involved in the selection of the tools (e.g. software) that were used by some participants to illustrate their ideas to the rest of their team, as shown in the example below. This was done in an attempt to mitigate some of the challenges of VDTs.

Using Software to Illustrate a Creative Idea

“Other creativity, how do you achieve the safety switch so that the blender does not begin without the blades being in a container, so the Budapest team drew a number of sketches to show the hidden switch and how it would be arranged, and they modelled it in 3D as well which was really creative, but the company agreed that this hidden switch mechanism has not been used for blender designs and recognized it was creative. I felt that creativity was really good and enhanced the overall concepts.” (student, phase 2)

Some of the concept ideas that were generated were rated very high for creativity:

Creativity through an Original Concept

“We had a very original idea, our product has a touch screen which looks reaaaaaaally good, we also put the disinfecting linkages inside, not in the toilet, which also looks nice, the perfume is installed in the flushing plate. This was the outcome of the team's creativity, not of a specific person. We reached to that by collecting results to see what was needed (phase 1) we decided we should do the disinfecting liquid and the perfume, then it was all a matter of constructing it. So, let's say we didn't have this idea on our own, we thought about what was needed too

and what was the best way to sell your product—which is to fulfil the customer's needs.” (student, phase 4)

One of the VDTs exhibited creativity by combining existing functions for multiple uses of the same product:

Creativity through Combination of Different Functions

“They were experimenting on how to use the actual blender, and they found that most of the times it's used to chop stuff up, but then they also saw it as a shaker, you know, to make cocktails. So they brought the two together, like that, and put the blade and the model on top and designed in a way that you shake it and move it around, so they put existing material together and made it work in a different way than before. How do you basically combine several different functions? By making the handles attachable they followed a new approach on it.” (coach, phase 3)

And interestingly, new technologies were applied to improve the practicality of certain products:

Creativity through the Use of New Technologies

“The blender teams also were creative: they took a look at some new technologies and how they could be implemented [...] taking a technology and implementing it to different places, by for instance, placing polymers that are flexible so you don't have a button, but you basically have a plate where you can push in, or e.g. through targeting a specific problem, that the button is hard to press” (coach, phase 3)

The examples above demonstrate that creativity was high in the EGPR and that it took many forms; from generating a creative idea regarding a concept, through to using new technologies or software to succinctly illustrate an idea to the rest of the team. Analysed and presented next are the factors influencing creativity in the EGPR VDTs.

6.5.4 Analysis of the Factors Influencing VDT Creativity

My analysis unearthed a number of factors that influenced VDT creativity in the EGPR. These factors had an enhancing, or an inhibiting role to play, or both in different situations. They were individual-, team-, and technology-related, and are presented below.

Individual-related Factors

It was observed that certain individuals were more creative than others. These individuals managed to shine through and express their creativity despite the virtual character of the project. In other words, to them, virtuality did not prevent them from being creative:

*“... virtual or not had nothing to do with how creative he was. His English was not good either but **he was a very creative designer**. The outcome was very creative, as we all expected.”* (coach, phase 2)

“... that machine was modelled from one person, who it was him who thought it, who sketched it and who modelled it.” (student, phase 2)

*“the multiple-function blender... he explained he wanted to combine different functions... **all recognized he was very creative, able and skilled**... from the sketches we couldn't see what he wanted to achieve, but when he modelled and presented it, we were able to see.”* (student, phase 2)

Communication, Engagement, and Organizational Skills

Overall, most participants agreed that each VDT would have one or two particularly creative individuals. However, given the high degrees of virtuality experienced by the teams at the first four phases of the EPGR, this did not always suffice. The findings highlight a number of characteristics, or enhancers of creativity at the individual level, that are necessary for creativity in a VDT environment. Without these characteristics, it is debatable whether the degree of creativity shown by the teams would have been likewise. More specifically, those with excellent communication skills were more effective in putting their ideas across:

*"Many times we have good ideas, but **some other can be more persuasive.**"*

(students, phase 4)

On the contrary, poor communicators did not manage to share their ideas with others or generate ideas through collaboration.

Others showed initiative and creativity in the way they communicated their ideas:

*"... **we used our hands in the VC and body language to explain our ideas.**"*

(students, phase 4)

*"I wouldn't say [language ability] was a factor; **the guys started using 'paint.'**"*

(coach, phase 3)

Therefore, communication skills—not necessarily oral, but also in terms of being able to identify the right media or methods for communicating your ideas—constitute an individual characteristic that is necessary for creativity in VDTs; as also does the level of engagement shown by some. In fact, the coaches interviewed made a clear distinction between those who were shy and relatively silent, and the more engaged ones; the latter took the liberty to challenge others' ideas, suggest ways forward, get other people involved, and inquire about the project. Their approach to the design task was more structured and they exhibited excellent organizational skills:

*"... there've been a couple of students that are very active, **they've been sending emails quite regularly to catch up on what has to be done, we need someone to do that.**"* (coach, phase 3)

Education- and Experience-related Knowledge

The issue of knowledge was associated with the participants' education and with relevant experience. For example, while mechanical engineers in the EGPR were unfamiliar with certain processes, industrial designers had received more focused training which helped them exhibit higher levels of creativity:

*"Industrial designers **are better-trained for brainstorming and generating ideas.**"*

(coach, phase 3)

In contrast, when referring to the rest participants, another coach argued that most students have not been trained for brainstorming at their home institutions:

“I had never done this kind of things myself before.” (student, phase 1)

Knowledge obtained from prior experience seemed to matter too. The individuals who had been involved in similar projects were found to be more creative in delivering their tasks:

*“[they knew] what colours to put there, also ‘Photoshop’; so if I did the brochures, it would all be one colour! [...] Their proposition was what the company wanted [...] they knew how to present it [...] initially I thought my design was the best, then I saw theirs and I realized they were a lot **more creative, and more experienced** of course.”*
(students, phase 4)

Interestingly, as one of the students noted, the project was highly divided based on the skills of each participant. For instance, industrial designers would typically attend to the aesthetic aspect of their ideas, whereas mechanical engineers, on the other hand, would deal with solving technical problems that would emerge:

*“[Industrial designers] did the posters and presentations. We made the first presentation, but when they saw it they cried a bit (laugh) and did it again from scratch—very creatively. **With the posters, it's the skills how you do it, you know what colours to put there [...]** But whenever there was a problem, we solved it.”*
(student, phase 4)

It follows that in addition to the participation of creative individual and relevant knowledge, in a VDT it is important that individuals be highly engaged in the task and show excellent communication and organizational skills. These characteristics were found to influence creativity positively in the EGPR and acted as enhancers of creativity.

Team-related Factors

Creativity at this level concerned: (a) ideas about their designs which emerged within a team situation, e.g. during brainstorming sessions (coach, phase 4); (b) ideas generated earlier by individuals, which were further developed by the rest of the team:

*“The idea was from one person but we had a lot of discussion with the coach and with professors too, we worked together to perfect this concept. **At the start it was one person but it evolved**”* (students, phase 4);

and (c) ideas about novel, or unexpected but relevant, methods the teams would employ, e.g. use of SWOT analysis (coach, phase 3).

The factors influencing creativity at the team level had an enhancing or an inhibiting role to play, or both, and are as follows:

Geographical Dispersion

The most evident factor influencing creativity at the team level was one that is strongly linked to virtuality; that of geographical dispersion:

“It's really hard to build something on three different computers [...] We agreed that we would do modelling at the beginning, then we decided it was their idea, so it would be better if they did modelling. Then we had to send them all files, version 1, 2, 3, and it became difficult, they had to do everything on their own. We had to put everything, the existing parts, to measure something and tell the others to model it. It's much easier if you do everything yourself. You do it yourself much faster.” (student, phase 4)

“if I made drawings, I would also have to describe them which takes a lot of time, if we were together in the same place it would have been a lot easier, you know you can easily say that's ok, that's not ok and go on like that.” (student, phase 4)

What is more, geographical dispersion exacerbated differences among the EGPR participants, including differences in education or conceptual understanding of the ideas:

"You can sketch something in front of someone and explain it more easily; e.g. we needed to develop a shaft but the people in Slovenia didn't understand and when we came here we saw something different. We went around the problem and changed it last minute. If we had it in our hands, it would have been easier." (student, phase 4)

Therefore, despite the use of technologies, geographical dispersion strongly inhibited teamwork and creativity at the team level. It exacerbated the negative effects of heterogeneity, and also, the participants felt that certain processes would be performed better individually—not in collaboration with others.

Heterogeneity, Subgrouping and Stronger Voices

The VDTs studied were highly heterogeneous. Heterogeneity in terms of educational background was what brought more ideas to the table, including not only design ideas, but also work approaches and methods:

*"... We used tools we hadn't used before. We checked what other competing companies, Bosch, Siemens etc. did to fulfil different functions, and using this checklist to enhance our creativity **was not something that I, as a mechanical engineer, had used before**; [...] Because we are from different backgrounds we consolidated each other; **this aided our creativity in the conceptual design**."* (student, phase 2)

Importantly, because of heterogeneity in terms of education, the team participants complemented each other:

"The difference between mech eng and industrial designers is how they focus on the things. So we, industrial designers, are focused on the problems, to solve them and then the solution. Mechanical engineers are focusing only on how to solve each function. We try to figure out something new, something innovative, something that does not exist at all." (student, phase 4)

Participants from different disciplines contributed different ideas:

"Especially the design students brought a lot of new tools that engineers were not familiar with; e.g. collages, taking a screw driver and thinking how you can fit this in

an actual blender; especially at the beginning (of the phase) this was a strong influence because everyone was working on the design” (student, phase 2)

It was also largely due to heterogeneity why subgroups were formed within the VDTs. Subgroups constitute subsets of team members that share a number of common characteristics, which enable them to distinguish themselves from the rest of the team. The participants felt more comfortable collaborating with participants with whom they shared common characteristics, including educational background and language spoken. Further to this type of subgrouping, based on common characteristics, subgrouping was also locational.

In some cases, subgroups were found to enhance creativity:

“...you can have [subgroups] bring something creative and new, instead of competing ...” (coach, phase 4);

*“In my group, 2-2-1-1-1, the guys who were together [...] were pulling the project forward [...] **the centre of creativity was there**” (coach, phase 2);*

*“It's always easier to have someone next to you to discuss. **You might have a quick idea and need to say: Hey listen, what about that???** It's hard to write this on the Internet, wait for a response, etc.” (students, phase 4)*

Therefore, subgrouping was found to soften the negative effects of virtuality and enhance the participants' creativity. Yet, subgroups within the teams also inhibited creativity. For instance, conflicts arose between subgroups, and this led to compromises and hard feelings between certain participants:

*“... two students from Ljubljana proposed a concept that others said it couldn't work [...] **they did some kind of compromise.**” (coach, phase 3)*

Further, certain subgroups developed stronger voices and became more authoritarian. In these cases, the isolated participants' ideas were not heard:

*“You've got two people from the same country and **they are having a bit of monopoly, they are trying to dictate things**” (coach, phase 3);*

*“coach and team leader were both in [location]. And then again, **three people, coach and two team leaders, based in a specific location has an influence on the outcome.**”* (student, phase 2)

What is more, the prevalence of the stronger voices led to less creativity in the teams:

*“The [X country] guys have strong opinions and find it difficult to get negative feedback, but are still very strong in the team. But **the team is not happy with the concept and at the moment we are working on a product that not everyone likes, and people are not that engaged or willing to be creative, they are not committed or happy.**”* (student, phase 3)

Subtask-oriented subgroups were also formed within the VDTs; these, however were not found to be effective as participants found it hard to overcome the challenges of geographical dispersion:

*“For me **it was a bit of a struggle because I am alone here**, it was very hard for me to work in a subgroup with a person from different location.”* (student, phase 2)

*“... [the subgroup] based in Budapest was working on 3D modelling, the Slovenian [subgroup] were working on the components of the accessories, so again this happened in most teams, it was done in pairs, and **I felt out of the equation, as I was alone here.**”* (student, phase 3)

Thus, the three types of subgroups I identified—(a) collocated subgroups; (b) subgroups from the same design discipline (engineers or designers); and (c) temporary subgroups working on a specific task—played a twofold role for creativity. Either *a priori* defined (regarding the first type), or emergently formed (second and third types), subgroups were found to be both enhancers of, and inhibitors to, creativity for the reasons outlined above.

Leadership Style

Leadership was typically exercised by more than one individual in each VDT. Each VDT had a pre-assigned coach, whose role was to monitor the team’s progress and

ensure their outcome would be creative enough. In addition, other leaders emerged during the VDT lifecycle in most teams.

Table 14: Leadership Styles Influencing VDT Creativity

Leadership Style	Definition	Explanation
Centred	Exercised by <i>One Participant</i> throughout the VDT Lifecycle	Having a Centred Leader (the coach) ensured consistency and constant emphasis on creativity during the VDT Lifecycle
Assertive	<i>Requesting</i> more creative outputs	Centred leaders were often found to put pressure on participants to generate more creative outputs.
Shared	Exercised by <i>Multiple Participants</i> throughout the VDT Lifecycle	Shared leadership was collaborative and based on expertise in the activities undertaken during a specific phase.
Subgroup	Exercised by a <i>Subgroup</i> within each VDT	Leadership was assumed by subgroups, e.g., when a certain few participants shared similar expertise in specific activities.
Emergent	<i>Allowing Individuals to Emerge</i> as Leaders at any stage of the VDT Lifecycle	Response to inability / unavailability of assigned leaders. Emergent leaders were usually accepted by their VDTs.
Democratic	Allowing Leaders to Emerge <i>regardless of pre-assigned roles</i>	The VDTs were accepting in terms of who emerged as a leader. This had a positive impact as all leaders were heard.

I posited a number of leadership styles that influenced the teams' creativity. While centred leadership was exercised by the coaches throughout the design process, the leaders that emerged during the different phases were based on the participants' strengths and knowledge. For example, designers were found to spearhead Phases 1 and 2 and mechanical engineers Phase 3. In some teams this was done collaboratively, but in other teams leaders emerged as no one would assume a leadership position:

*"We tried to set different leaders for different phases, but **the others [...] didn't know how to deal with leadership so I stepped in.**" (students, phase 4)*

While, therefore, leadership within the teams was found to be centred, shared, collaborative and also emergent, leadership regarding the coaches' input was participative and motivational—in that they would incite the participants to go the extra mile in order to reach their creative potential:

“We had to push them a bit ... I gave them some ideas to get going. Also we debated a bit so that **they started thinking**, to get the kick off. Or say, listen **this is not innovative enough, think of something different.**” (coach, phase 2)

A summary of the leadership styles and the type of influence they exerted over the participants' creativity is presented in Table 14.

Technology-related Factors

Technology in VDTs provides the platform with which VDTs overcome geographical separation and manage to *get together* and collaborate. However, technology, and its varying forms and features, was not always found to have a positive influence on the participants' creativity. I discuss the role played by technology predicated on its degree of synchronicity:

Synchronicity

Synchronous Computer-Mediated Communication (CMC) refers to the tools that allow for real-time communication, with the VC being the most commonly used one and Skype VC constituting a synchronous CMC tool the participants used rarely. The participants gave mixed views regarding the relationship between degree of synchronicity and creativity. On the one hand, high synchronicity created an artificial environment where attention had to be paid to factors other than the purpose of the virtual meeting itself, thereby making the participants lose focus and be unable to generate ideas at the same pace as they would in a F2F environment:

*"[With VC]... it was sometimes very difficult to transfer your thoughts [...] when you are in a meeting you know you are there and you pay extra attention, **but in the VC you are not as concentrated, which has decreased our instant creativity.**"* (student, phase 2)

The artificial environment created by the VC raised another hurdle to the participants; one they could not fully articulate, but which arguably has to do with the lack of the visual dimension:

*"The problem in generating ideas [...] is hard when you're not in the same room. We couldn't do it in the VC. It's much harder to explain everything. I think it's always better to have another computer **where you can see what they are doing.**"* (students, phase 4)

In addition, the participants argued that creativity was rare during the VC meetings, because:

*“Sometimes you can be creative when you are in the shower or in the morning when you wake up. But when you are in a meeting, **you are time-limited and there is pressure**, which I think it's not good for my creativity.”* (student, phase 4)

It should also be noted that technical problems were also posited and found to inhibit the participants' creativity during their synchronous communications:

*“VC is not as good, because **connection is not always good, and not everyone speaks English very well** so we don't always understand.”* (students, phase 4)

As one of the coaches argued, however, the VC sessions were not to be creativity-oriented, but had a different purpose:

“At the [VC] meetings, they have discussions about project management issues, deadlines, who will do what, when, how, these are the main issues they discuss at the meetings.” (coach, phase 3)

“VC we talked about the important things; we had to focus on the important points; the tasks, who would be responsible, and so on.” (student, phase 4)

However, others claimed that it was because high synchronicity why they remained focused and able to generate ideas within the timeframe of a VC meeting:

*“... **we were fully concentrated on [the VC]. We knew the time constraints and we tried to solve all the problems within the time we had. In other situations, I would rather postpone it rather than solve it straight away.**”* (student, phase 4)

For some participants, the biweekly VC meetings, and the personal contact attained within each, served as a tool for organizing their creativity:

*“Usually on the VCs we would agree what ideas we should have developed by the next VC. So **we were kinda forced to come up with new ideas for next time. This made us creative.**”* (student, phase 4)

Overall, the issue of synchronicity—and the use of VC meetings more specifically—had a twofold effect on the participants' creativity. On the one hand, the participants

found that: (a) they were less concentrated on creativity during their VC meetings, because their attention was elsewhere; (b) synchronicity did not afford all dimensions of F2F communication, as, for example, it raised visibility barriers; (c) there was time pressure; (d) technical issues (e.g. reduced quality on the VC) exacerbated language issues and influenced creativity negatively; and (e) the VC in particular was not designed to enhance the participants' creativity, but its role was mainly coordination-related. On the other hand, however, some participants were motivated by the constraints raised by the use of the VC; they viewed the use of the VC as the only opportunity during which they could be creative as a team and were therefore highly creative during these sessions.

Asynchronicity

Asynchronous CMC refers to the tools that do not allow for real-time communication (e.g. email) and which can be used at random times among the participants. Most commonly, the students used email and Skype, but also Huddle on which they could upload files of their sketches and receive their teammates' comments at a different time, thus attaining creative teamwork asynchronously. The main advantage offered by the asynchronous character of these technologies is that the students were able to be creative regardless of their teammates' availability. Oftentimes, this was in the middle of the night or early in the morning. As a student put it,

*"... [The issue of asynchronicity] was good because I **could have a good idea at random times** and then I could send it to others at a different time. Flexibility combined with schedule and technology are good for creativity."* (student, phase 4)

Still, the issue of asynchronicity augmented the sense of artificiality in their CMC as it involved activity that in a F2F would not be necessary:

*"[you have] **to go to a different room, scan your sketches, send them [...]** in the conceptual design phase, **uploading a sketch makes you lose track.**"* (students, phases 1, 4)

Further to the individual-, team-, and technology-related factors, and the design task and the design process analysed earlier, I also posited project importance, external

commitments, and the industrial partners as factors influencing creativity. With the exception of task and process, which relate to the team level, importance and partners would relate to the organizational level of creativity in an industrial VDT context. Given, however, that an educational context is used to research VDT creativity, and that raising pedagogical implications is beyond the scope of my study, I do not discuss these issues further.

The factors that were found to influence creativity in the EGPR are presented, and briefly explained, in Table 15 below.

Table 15: Factors Influencing VDT Creativity in the EGPR

		Enhancers of Creativity		Inhibitors to Creativity	
		Major	Minor	Major	Minor
Individual		Participation of Creative Individuals: One or Two in Each VDT Relevant Knowledge: Education- & Experience-related Communication Skills: Oral & Creative	High Task Engagement: Showing Initiative Organizational Skills: Coordinating the VDT		
		Centred Leadership: Coach Responsibility from Start to End (Participative & Motivational) Heterogeneity: Knowledge Sharing; New Ideas; Germane Distribution of Tasks Shared/Collaborative Leadership: Leading based on Strengths/Expertise	Emergent Leadership: Allowing & Encouraging New Leaders to Emerge during the VDT Lifecycle Subgrouping: Mitigating the Negative Effects of Geographical Dispersion & Heterogeneity	Geographical Dispersion: Reducing Teamwork; Exacerbating Participants' Differences Locational Subgrouping: Developing Feelings of Isolation; Leading to Imbalance Stronger Voices: Not allowing all ideas to be heard; Disappointment	Heterogeneity: Misinterpreting Concepts & Ideas
Team	Synchronicity		Synchronous CMC: Seen as Opportunity for Creativity Synchronous CMC: Fostering a Spirit of Commitment & Responsibility toward Creativity	Artificiality of Synchronous CMC: Losing Focus; Missing the Visual Dimension; Technical Issues	VC Constraint: Time Pressure VC Purpose: Coordination-related
	Asynchronicity	Asynchronous CMC offering a Flexible Approach To Creativity: Sharing Ideas irrespective of Teammates' Availability		Artificiality of Asynchronous CMC: Losing Track due to Additional Activities involved in Asynchronous Communication	

6.6 Reflection on, and Strengths of, Study 1

With Study 1 a first step was made toward a better understanding of creativity in the VDT context. This study is significant for a number of reasons, outlined below.

First, the VDTs studied here are truly global VDTs, drawing on participants from different nationalities and cultures, who are natives of different languages and heterogeneous in terms of several aspects, such as educational background. This, coupled with the fact that the VDTs used a combination of both asynchronous and synchronous ICTs, as well as F2F communication, in Phase 4 and throughout the VDT lifecycle within their physically collocated subgroups (Panteli and Davison, 2005), advances relevant literature on VTs, and, significantly, literature on VT creativity that has been, to date, limited to the investigation of national (not global) VTs using asynchronous ICTs (no synchronous ICTs or F2F communication) only (Chang, 2011; Ocker, 2005). Further to informing relevant literature, this type of VDT is one that is closer to what is often encountered in industry—not only in design but in other domains too.

Second, Study 1 is the first to look into the relationship between creativity and the VDT lifecycle, contributing to relevant literature (e.g. Hertel *et al.*, 2005). Based on the interview data and my own observations, I delineated (Figure 22) the impression of creativity fluctuating throughout the VDT lifecycle. What is particularly important is that I conducted interviews after each phase of the VDT lifecycle, adding to the accuracy of my impression of creativity. It is shown, for example, with my findings, analysed earlier, that creativity was not always high; two particular moments in which creativity peaked were the conceptual phase of the design process, in which the participants were tasked with concept generation, and also during the latter stages when the participants got together in a F2F environment to complete their tasks.

Third, an open approach (e.g. making no reference to virtuality when interviewing) and interviewing style (e.g. asking open-ended questions) was adopted that enabled me to capture all factors perceived by the participants to influence creativity. Thus, the factors elicited were not strictly related to the virtuality of the VDTs, but may

have been relevant in any context, virtual or not. This approach contributes to current literature (on virtuality and also on creativity) as it shows which factors of the ones found in the traditional creativity literature (e.g. Amabile, 1988; Andriopoulos, 2001) are also significant in the VDT context.

Fourth, of the factors that were elicited, a number of factors were found to be strongly linked to virtuality (e.g. geographical dispersion). Given that no other study focusing on VT creativity has looked into the relationship between creativity and virtuality, my findings from Study 1 are important, as they are the first to start promoting a better understanding of this relationship.

Fifth, this exploratory case study with the EGPR—further to its strengths and contributions outlined above—helped to assess the effectiveness of the methodological approach taken and revise it for the following two case studies.

6.7 Onward

In the present chapter, I have presented the first case study I conducted and have outlined its strengths and significance for the field. Building on the lessons learned from Study 1, I proceed to the presentation of the second case study I conducted to address the RQ and objectives of the thesis, in which I employed an improved, and more focused, methodological approach through the investigation of a single global VDT in a similar educational context.

Chapter 7: Case Study 2—ESTIA24

In this chapter, I present a case study I pursued in order to further understanding of creativity in Virtual Design Teams (VDTs) building on Study 1. I start by presenting the research site and I move on by introducing the team under investigation, discussing the data collection and analysis processes, and presenting findings that emerged from the analysis. I close the chapter with a reflection on the case study.

7.1 Research Site: ESTIA24

The ESTIA 24h of innovation (henceforth shortened to ESTIA24) is a 24-hour (24h) challenge developed in 2007 by the *École Supérieure des Technologies Industrielles Avancées* (ESTIA; English: Engineering Institute of Advanced Industrial Technologies), situated in Bidart, France. Since its establishment in 2007, the ESTIA24 organizers have been inviting every year proposals from companies and associations on ideas and concepts the latter (companies/associations) want to implement, but have not done so as they may lack time and/or resources. As it appears in the call for proposals, “... *You have an idea or a new concept of innovating product, a creative topic of R&D, a need... You do not have time or available resource to work on this subject? [...] Submit your proposal, it will be studied with discretion by the Organization Committee and will be proposed to one or more development teams!*” (ESTIA24 website). Once they have sufficient product/service concepts and they have secured a number of sponsoring bodies (e.g. for 2010: the European Union, Thales, HSBC, Orange), they develop a document listing these concepts (incorporating title, design brief, and illustration for each) and they invite participants (mostly students, but also professionals) to register for the ESTIA24 challenge and engage in a non-stop 24h-long design activity at a team level. ESTIA24 has attracted media attention (e.g. in local online media, in local press such as *SudOuest*, and internationally in over 80 countries) and it has been also organized in Montreal, Canada in spring 2010 (links provided in Appendix C).

7.1.1 ESTIA24 Organization

The challenge, which takes place every autumn, commences with an introduction (delivered in French) to the structure and expectations in Bidart (teams situated elsewhere attend it via Skype) and during the first hour of the challenge teams of approximately ten registered participants are formed (by the organizers) and are given the aforementioned document listing the concepts so they can choose and design one. Due to its non-stop character, the challenge entails a plethora of activities which go beyond the design task itself and are not normally encountered in working contexts; these might, among others, be sleeping or playing music, and constitute expected behaviours in the ESTIA24 context (Figure 24).

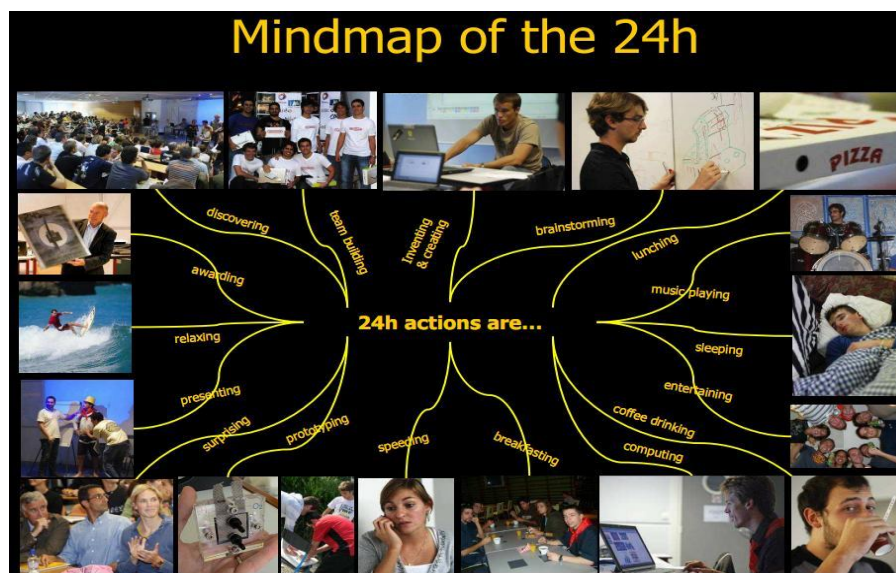


Figure 24: The ESTIA24 Mindmap (ESTIA24 website)

Therefore, the participating teams are given high levels of autonomy in terms of practices and structure, and the 24h are followed by presentations of the designs, and an evaluation made by a panel of innovation experts. Most participating teams are based in the ESTIA24 premises in Bidart, France and are provided with meals and materials. The ESTIA24 character is informal, educational and enjoyable, and it is meant to encourage creativity: "... **a dynamic and exciting event to promote creativity in the friendly environment**" (ESTIA24 website). The teams that perform best are given awards: e.g. *best technical concept*, *best marketing concept*, *best eco-innovation*, *best presentation*; and prizes from the sponsors.

7.1.2 ESTIA24 Suitability

It was agreed with the ESTIA24 lead organizer that a VDT would be formed between two countries (the UK and possibly France or Spain). Further, therefore, to the flexibility offered to me in requesting a VDT configuration which would satisfy certain requirements—and the ESTIA24 rules which allow the involvement of coaches and researchers in the challenge if for research purposes (ESTIA24 website)—there are a number of reasons that render ESTIA24 a suitable research site for this stage of this research. I outline them below.

Drawing on Panteli's (2004b) Virtual Team (VT) typology model, among other literature, the formed VDT is: (a) an inter-organizational one between two universities (as described below in further detail); (b) a temporary one with very short duration (Tong *et al.*, 2013); and (c) an international one as it comprises members based in different countries and of different nationalities, which means that cultural diversity is augmented. Drawing on Griffith *et al.*'s (2003) dimensions of virtuality model, it is one that combines pure virtual (between the two physically collocated subgroups) and traditional (Face-to-Face (F2F), within each subgroup) elements. Thus, the ESTIA24 VDT constitutes a configuration that can be characterized using existing frameworks.

It is held in a quasi-educational environment where the participants are students (at least in the VDT under investigation and in the vast majority of the participating teams) studying for an engineering degree. These similarities mean that analysis of ESTIA24 will produce findings comparable to, and will enable me to build on, those from Study 1.

Contrary to Study 1, however, the participants in ESTIA24 are not after good marks as this is a challenge they agree to undertake on a voluntary basis in order to enjoy, learn, and enhance their practical experience, and not to in order to be assessed as part of their degree. In fact, though in their vast majority the ESTIA24 participants are students, the ESTIA24 call for participation highlights that the challenge can also be undertaken by researchers, professionals, and others. Therefore, the pedagogical aspect which was acknowledged as a limitation in Study 1 is not present in its

entirety in ESTIA24; though, as per ESTIA24's website, one of the aims of the challenge is to educate—and despite the final evaluation which might equate to a university form of assessment, and potential awards—the ESTIA24 participants' principal aim is merely to accomplish a task and show their creativity. In all, the pedagogical limitations characterizing Study 1 are largely removed here.

Another similarity lies in the temporal dimension of VTs identified in the VT literature. ESTIA24 is (similarly to Study 1) a temporary VDT, as were the teams in Study 1, but due to its very short duration, it offers the advantage that most of the formed VDT's activity can be recorded and looked into closely. This differentiates ESTIA24 from other similar projects, while recording the design process in a VDT environment would have been extremely hard in a VDT of longer duration.

The VDT under investigation falls into the Partially Distributed Teams (PDTs) type of VTs (Ocker *et al.*, 2009a). In Study 1, the EGPR organizers aimed for maximum geographical dispersion for each team, though in most teams locational subgroups were formed for functional reasons of the EGPR (i.e. overabundance of students in certain locations). Here, the VDT under investigation is composed of two geographically dispersed subgroups, which means that its members are partially distributed and—as opposed to Study 1—no isolated members are found in any of the two locations. Such a configuration suggests that the VDT members sharing the same location enjoy the luxury of potentially unlimited F2F communication and interaction which features in the literature as the richest type of communication (Workman *et al.*, 2003). Overall, selecting this certain type of VTs—a PDT—will extend the value of this study, and our understanding thereof, into an additional type of VTs.

7.2 The VDT under Investigation

ESTIA24 commenced at 13:00 GMT on 22 October 2010 and comprised 26 teams of approximately 300, largely Francophone, registered participants. The teams were formed either in physically collocated or geographically dispersed, and thusly computer-mediated, environments, and my case study involved a team of ten undergraduate students, composed of two geographically dispersed subgroups (Figure 25): a UK one comprising five students (University A) and a French subgroup comprising five students (University B). Though the students from each location knew each other (to varying degrees) and had shared part of their degree syllabi over the last few years, the two subgroups shared no working (or other) history with each other and were not expected to collaborate again in the future. Thus, the two subgroups were brought together with clear start and end points; for the purpose of the ESTIA24 challenge only.

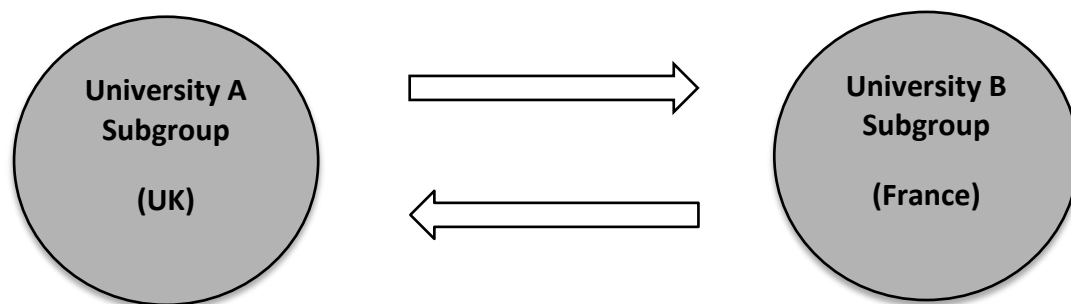


Figure 25: The Two Geographically-dispersed Subgroups

Recruitment of the University A participants was performed by my lead supervisor, who had recently acted as their University lecturer, on the basis of performance in their studies, potential for creativity, overall aptitude and calibre, and willingness to take on a challenging task as an extra-curricular activity. They agreed to partake voluntarily in the challenge because their participation would be a significant achievement for them to include in their portfolios, considering they were all in search of jobs for the subsequent year. Each participant signed an in-house ethics form (Appendix D), allowing me to record their activities over the 24h and use the

collected data for research purposes. It was also agreed that they would be provided with dinner and breakfast during the activity, as well as with any material required.

The University B participants, on the other hand, were recruited by the ESTIA24 lead organizer in the French site on the basis that (a) their level of English would be sufficient to collaborate with Anglophone (and international) students; (b) they would have the Information and Communication Technologies (ICTs) needed to make the task virtual; (c) they would have no objection for their virtual activity to be recorded and used for research purposes; and (d) they would be prepared to add another challenge to the already challenging task—that of performing design virtually. A sample of my communications with the ESTIA24 lead organizer prior to the commencement of the challenge can be found in Appendix E. Though the activity of the University B participants was not looked into closely, as was that of the University A participants', but only during the Video-Conference (VC) and Skype sessions had between the two subgroups, their involvement was significant because it was what enabled the formation of the VDT under investigation. I now move into a discussion of the individual- and team-level characteristics of the VDT under investigation in some depth.

7.2.1 The ESTIA24 Participants

Though the University B participants were emailed twice upon completion of the ESTIA24 challenge, being requested to send an individual email each outlining their personal characteristics (e.g. age, subject studied), they never responded. Insofar as the University A participants are concerned, they were highly homogeneous in most respects: nationality (with one exception of a Chinese student whose mother tongue was other than English), gender, age, and subject studied (Table 16). The mere variance among them lied in whether they had taken a specialism or had chosen to pursue an industrial placement for a year, which also impacted the number of years they studied for their degree. In presenting the University A participants, I altered their real names to protect their anonymity, keeping the initial letter of each name alike to reduce confusion whilst performing the analysis. Their age is at the time of the challenge—namely October 2010.

Table 16: Presentation of the ESTIA24 University A Participants

Name	Nationality	Birthplace	Mother Tongue	Gender	Age	Subject	Specialism	Placement	Year
Craig	British	UK	English	M*	22	Mechanical Engineering	Advanced Design & Innovation	N**	4 th
Dylan	British	UK	English	M	23	Mechanical Engineering	Advanced Design & Innovation	N	4 th
Henry	Chinese	Hong Kong	Cantonese	M	24	Mechanical Engineering	-	Y**	5 th
Ryan	British	UK	English	M	23	Mechanical Engineering	-	Y	5 th
Sean	British	UK	English	M	22	Mechanical Engineering	Advanced Design & Innovation	N	4 th

*M = male, F = female; **Y = yes, N = no

7.2.2 The Design Task

All participating teams were emailed a document listing 34 product/service ideas—that originated from the earlier call for proposals for ideas to companies and other organizations—15 minutes upon commencement of the challenge, during the introductory first hour of the 24h. The VDT decided on the following task: **an eco-citizen object** (Figure 26) whose brief was the only out of the 34 lacking an illustration, highlighting the complete freedom for creativity as to how the outcome would look; at least according to the interpretations of the University A participants, as I will be discussing below. After discussions within and beyond each subgroup—and further questioning regarding their choice—the team felt confident that this was an appropriate design idea to pursue.



Figure 26: The Design Task: An Eco-citizen Object (document extract)

7.2.3 Geographical Dispersion and Location

As mentioned earlier, one subgroup was based in the UK and the other in France. The former used University A's premises and worked from a workroom of the Faculty of Engineering and Design which is predominantly used for VC meetings. The workroom was equipped with the VC system and screens, and contained several desks which the participants rearranged so they would be able to work conveniently over the 24h, as they would need to hang posters on the walls, work individually on their laptops, and get together when needed to engage in team activity. They also had access to outside areas for rest and to additional facilities (e.g. laboratories) to produce their prototypes at the latter stages of the challenge. The University B participants seemed to work from a similar workroom in which they stayed for the whole duration of the project. Their workroom was situated in the ESTIA24 premises in Bidart, France.

7.2.4 Methods of Communication

The University A participants were given limited access (i.e. 4 hours) to an IP-based VC system (Figure 27) and they were given the autonomy to distribute the time themselves over the 24h of the challenge, in concert with the University B participants.



Figure 27: The Two Subgroups together on the VC (video data)

VC use was limited because it was expensive to use and my research budget did not suffice for 24h of VC use. This constraint brought the ESTIA24 challenge closer to industrial practice, as in no known projects VDTs make use of synchronous communication all through the VDT lifecycle. Barring this imposing instruction, the VDT participants were instructed to determine themselves the ICTs they would use to accomplish their selected design task. Therefore, further to VC'ing—which constituted the VDT's preferred ICT—they also used emails (minimally), and Skype synchronous communication (VC) and features of less synchronicity (Instant Messaging (IM), documents exchange), as well as YouTube. The latter was used at the latter stages, when the University A participants wished to communicate to their University B teammates their ideas about the final presentation video. Evidently, the VDT only used ICTs to communicate and collaborate, as this idiosyncratic VDT configuration did not permit any F2F communication between the two subgroups.

7.3 Data Collection Process

Table 17: Detailed Data Collection Table

Data Source	Data Type	Collection Instrument	No.	Length
Video Recordings	IP-based VC	Video camera	8 sessions	175 mins
	Skype VC	Video camera	5 sessions	125 mins
	University A interactions	Video camera	-	485 mins
	Computer-Aided Design (CAD) Work	Panopto	Insignificant	Insignificant
	Internet research	Panopto	9 sessions	660 mins
Design and Communication Outputs	Skype IM	Forwarded	5 dialogues	-
	Emails	Forwarded	3 emails	Insignificant
	Photographs	Manual Coll.	74 files	-
	Physical drawings	Manual Coll.	6 drawings	-
	Logbook notes	Manual Coll.	5 items	5 pages
	Flipchart notes	Manual Coll.	14 items	-
	Post-it notes	Manual Coll.	117 items	-
Interview Data	Individual interviews	Voice-recorder	5	~ 100 mins
	Informal discussions	-	Unrecorded	Unrecorded
Supporting Material	Observations	Logbook	-	8 pages
	Design briefs doc.	Manual Coll.	1 brief	1 page

I set out to employ multiple data collection methods that would enable me to gauge the team's virtuality and creativity—and the interplay between them—in order to overcome some of the limitations of Study 1. However, the data collection methods I employed are limited to the University A participants' activity and their interactions with the University B participants. In other words, my approach did not allow me to capture University B in-subgroup conversations and/or brainstorming activities or drawings, as I was based in the UK site together with the University A participants. However, even if the geographical barrier had been overcome, this would have still

been unfeasible, because the University B participants did most of their work in French. Therefore, I came to recognize one of the major limitations of this study prior to the ESTIA24 commencement. Overall, with the exception of information I gathered from the ESTIA24 website, and conversations with the ESTIA24 lead organizer, the types of data I collected can be grouped into the following categories: (a) video recordings; (b) written outputs; and (c) interview data (Table 17).

7.3.1 Collection of Video Recordings

Video recordings constitute the team's (the two subgroups') interactions in speaking and were generated using a departmental high quality video camera on a tripod which captured most brainstorming and get-together sessions of the University A participants and all the interactions between the two subgroups, attained via VC'ing. They therefore combined audio and visual material. Unexpected technical difficulties as well as time constraints concerning the use of the VC system led the team to use Skype VC too on a few occasions. This was recorded both with the video camera and by the participants themselves using Panopto—a software program *a priori* installed on their laptops—that captures screen and audio activity. Panopto proved useful as it captured the participants' activity when doing research on the internet using their laptops, as this contributed to them exhibiting creativity. However, due to the participants' freedom as to when they could switch this software on/off, records of Computer-Aided Design (CAD) work were very limited, insofar that I came to consider them insignificant for the team's creativity. The above data collection process was facilitated by: (a) my lead supervisor who visited three times (start-mid-end), provided extra materials when needed (e.g. post-it notes, markers), and gave further guidance and tips; (b) my own observations which were kept in a logbook in chronological order; and (c) colleagues who visited and ensured the technologies used would work properly.

7.3.2 Collection of Written Outputs

Written outputs concerned all written communications between the two subgroups (i.e. emails, Skype IM); as well as some of the design outputs. Concerning communication, Xobni had been installed on the participants' laptops to count, measure the frequency of, and record their email activity, but the participants found its use confusing and instead forwarded all their written communication to me once the challenge was over. Admittedly, the volume of the communication-related written data was substantially lower than the other types of data, and the number and content of emails exchanges, in particular, were insignificant for my analysis. Concerning design outputs, I collected *a posteriori* all physical drawings (made on flipchart papers) the University A participants produced while engaged in brainstorming activity, as well as all their post-it notes, their notes on flipchart papers, and their notes on pages from their notebooks, where they jotted down their ideas during the 24h. I also collected photographic evidence of the latter which helped me reassemble the physical drawings and identify the time slots during which they were produced.

7.3.3 Collection of Interview Data

In addition to informal, unrecorded discussions I had with the University A participants prior to the challenge, where I gathered useful background information about each, once the challenge was over, I invited each to an individual interview to get their reflections on the challenge. The interview style I adopted was conversational and informal, with each interview lasting 20 minutes on average. The interviews were semi-structured and the open-ended questions I asked had a twofold aim: (a) to get to know their participants and gather background information (educational, placement-related, personal); and (b) to gather their perceptions of how their creativity had been influenced during the 24h-long design process, with emphasis on the virtuality of their team, consistent with the aims of this study. More specifically, my questions addressed the following:

- What were their expectations prior to the challenge;
- How was their experience and what were the challenges they faced;
- What did they think about the virtual aspect of the challenge and whether they could relate this to previous experiences they had;
- How were the group dynamics within and beyond their subgroup;
- What was their opinion on the task and its creativity;
- What are two examples of creativity, ideally one high and one low; and
- What was their overall reflection, and whether they would do it again.

Having spent 24h with the participants resulted into an informal interview style where each participant expressed their opinions freely and gave honest responses and examples. For instance, though I took for granted that the University A participants got along well with one another, and I persisted in wanting to understand more about their collaboration with the University B participants, the interviews revealed that even within the University A subgroup itself collaboration was not always exemplary. Further, though the rationale for pursuing the interviews

was partially to examine the consistency between my own observations (based on the datasets outlined earlier), and the University A participants' perceptions—thus for data triangulation purposes—by extracting their opinions and stories, the participants emphasized different aspects of their ESTIA24 experience; for example, some insisted on explaining why they did not contribute a lot to the challenge. Next I discuss how these data were analysed.

7.4 Data Analysis Process

7.4.1 Analysis of Video Recordings and Design Outputs

I initially watched all the recordings and extracted and counted the ideas the participants generated—individually or in their subgroup environment. Typical phrases when coming up with a new idea were: *“How about... What if...”* Watching the recordings and looking into my logbook observations taken throughout the 24h enabled me to identify the different stages of the 24h-long design process and place them under the phases during which they were generated. The first level of coding of these data aimed at discerning design-related ideas from ideas that were irrelevant to design. The various stages of the design process were initially indicated on a timeline I drew on four large flipchart papers (24h broken down to four 5h-long timelines; see Appendix G).

I subsequently wrote down all ideas on red (design-related ideas) and blue (other, principally management-related ideas) post-it notes which I stack on the timeline drawn on the flipchart papers (see example in Appendix F). I used the same papers to indicate the environment in which each stage took place (e.g. F2F, virtual) and the medium (if any) through which it occurred, and I used markers of different colours in order to be able to distinguish the different codes (i.e. design vs. other, F2F vs. virtual, synchronous communication vs. asynchronous). Once a clearer picture of the project and the progression of the ideas had been painted, I inserted the above into an Excel spreadsheet (Appendix G), together with the data from the design outputs and remaining video recordings. Again different colours were used to indicate the different types of environments, activities, and ideas (Appendix H).

The ideas extracted from the written outputs were identical to those identified in the recordings, which corroborates the reliability of the earlier findings. Once all ideas were placed rightly where they belonged (in terms of time during which they were generated), I attempted to trace all ideas and understand which of them were combined, died, or survived to the end, in order to attain a deeper level of granularity, compared to Study 1, as set out in the introduction of the chapter. I lastly looked at finished ideas backwards using the Excel spreadsheet and pursued a

short illustrative analysis in the form of a story, explaining the role of the different phases of the design process and that of virtuality in developing creativity throughout the 24h. Though I performed most of this data analysis process manually, Excel proved useful when the dataset began to become bigger (Appendix G).

7.4.2 Analysis of Video Recordings and Interview Data

Insofar as the remainder of the obtained data are concerned—i.e. the management-related ideas I extracted from the video recordings, and also the interview data—I used thematic analysis for the coding process, involving open (irrespective of literature) and axial (informed by literature) coding. In what follows, I explain how I performed this process on the two types of data I analysed thematically.

Concerning management-related ideas I extracted from the video recordings, I performed open coding on the themes that emerged. They were later put together into three categories (communication, collaboration, and work organization) following an open coding approach which, at that stage, was not influenced by my knowledge of the relevant literature, but was instead purely based on my interpretation of the issues the team faced during the 24h. These categories constitute the management issues influencing the team's creativity, which I subsequently coded axially, relating each of them with a certain characteristic of virtuality, drawn from the virtuality literature. The characteristics I unpacked were: language, CMC, temporal character, boundaries; and are all recognized issues in the virtuality literature. I performed this thematic analysis on the spreadsheet with no use of additional software.

Concerning the interview data, once I transcribed all five University A participants' interviews, I inserted the raw data into QSR NVivo 9 for analysis. I commenced the interview data analysis once the previous data had been analysed in order to reduce the level of influence of the participants' perceptions over my own interpretations of the design process. I listened to the interviews twice, initially as an attempt to be reminded of the actual 24h, and my involvement in it, and later to transcribe the interviews. During the analysis process, I had to listen to selected parts of the interviews again in order to reassure myself of what was being communicated to me by the participants. I initially performed open coding manually using hard copies of the transcripts, by circling and/or highlighting keywords and/or phrases I considered to be related to the issues under investigation. Different colours were used for highlighting to facilitate the process. This coding drew, therefore, on the

interviewees' own words, and the categories that emerged varied from communication to being separate, and from culture through to VC and language. Open coding was not limited to quotes of the interviewees' perceptions, but it also involved examples and stories they shared with me to illustrate the arguments they made.

I subsequently performed axial coding, relating each, or collections, of these categories to aspects of virtuality found in the literature. NVivo helped in organizing the codes produced at that point as well as in writing up the analysis as I had to go back to the coded data several times. The final codes that emerged at that stage were: separation, CMC and cross-boundary dimension. Axial coding took the form of both flat, or non-hierarchical, coding and hierarchical too. For example, the issue of separation was posited both between the two subgroups, as well as between one subgroup and the main site. This was an example of flat coding. By contrast, the cross-boundary dimension was found to involve sub-codes, including subthemes such as cultural and educational dimensions, and was therefore hierarchical. Overall, my thematic analysis, influenced by Braun and Clarke (2006), evolved over a period of time spent trying to deepen my understanding of the interview data and revising the relevant literature. The final themes built on both data and literature and were produced in order to pursue a better understanding of the relationship between creativity and virtuality.

In addition to the analysis described above, which was centred on the relationship between virtuality and creativity, there were two notions that emerged recurrently: the roles enacted by the design task and by the individual. It was found, in other words, that task and individual were two factors exerting a significant level of influence on creativity. The unpacking of these two factors is also reinforced by my own observations and notes from the 24h.

7.5 Analysis and Findings

In this section, I present the findings from my study with ESTIA24. I begin by providing a rundown of the 24h, involving the design phases and activities, in order to give the reader a feel of the challenge. In continuation, I present the large number of ideas the team generated and I show how creativity occurred in the form of a story. I thereafter move to a discussion of a number of management issues found to influence creativity in the VDT under investigation, and highlight their relationship with virtuality. I then present two factors that emerged as exerting significant influence on creativity and I lastly discuss how the unique characteristics of virtuality influenced creativity.

7.5.1 The 24h-long Design Process and VDT Lifecycle: An Overview

Per the design literature, the VDT design process can be seen as having taken the form of a simple three-phase model incorporating the task analysis phase, conceptual design phase, and the product development phase. Notably, however, the three phases had no clear start and end points. For instance, the first brainstorming session was conducted while the team were still trying to make sense of their task. Similarly, using a VDT lifecycle perspective to look into this, certain phases of the VDT lifecycle were also blurred. For example, the preparations or technologies used throughout the VDT lifecycle were not decided upon prior to the start of the project, but were re-negotiated on an on-going basis throughout it. Nevertheless, below I discuss the three phases I identified in order to give the reader a feel of how the team worked, what activities they engaged in, and the extent to which the two subgroups worked together. Describing the design process serves as a means for understanding and also positioning creativity within the lifecycle of the VDT under study.

Task analysis phase – hours 13:00-17:20

The challenge commenced @ 13:00 with a 1h-long presentation to all participating teams which took place in the French site and to which the University A participants, and other teams that were not based in France, were invited through Skype. Technical difficulties, alongside the fact that there was no English translation of the presentation, meant that the challenge did not start as well as it could have. The first sign of enthusiasm, when all participants smiled and applauded, was @ 14:45 once VC communication had been attained and whereby the two subgroups that would form the VDT for this study met electronically for the first time.

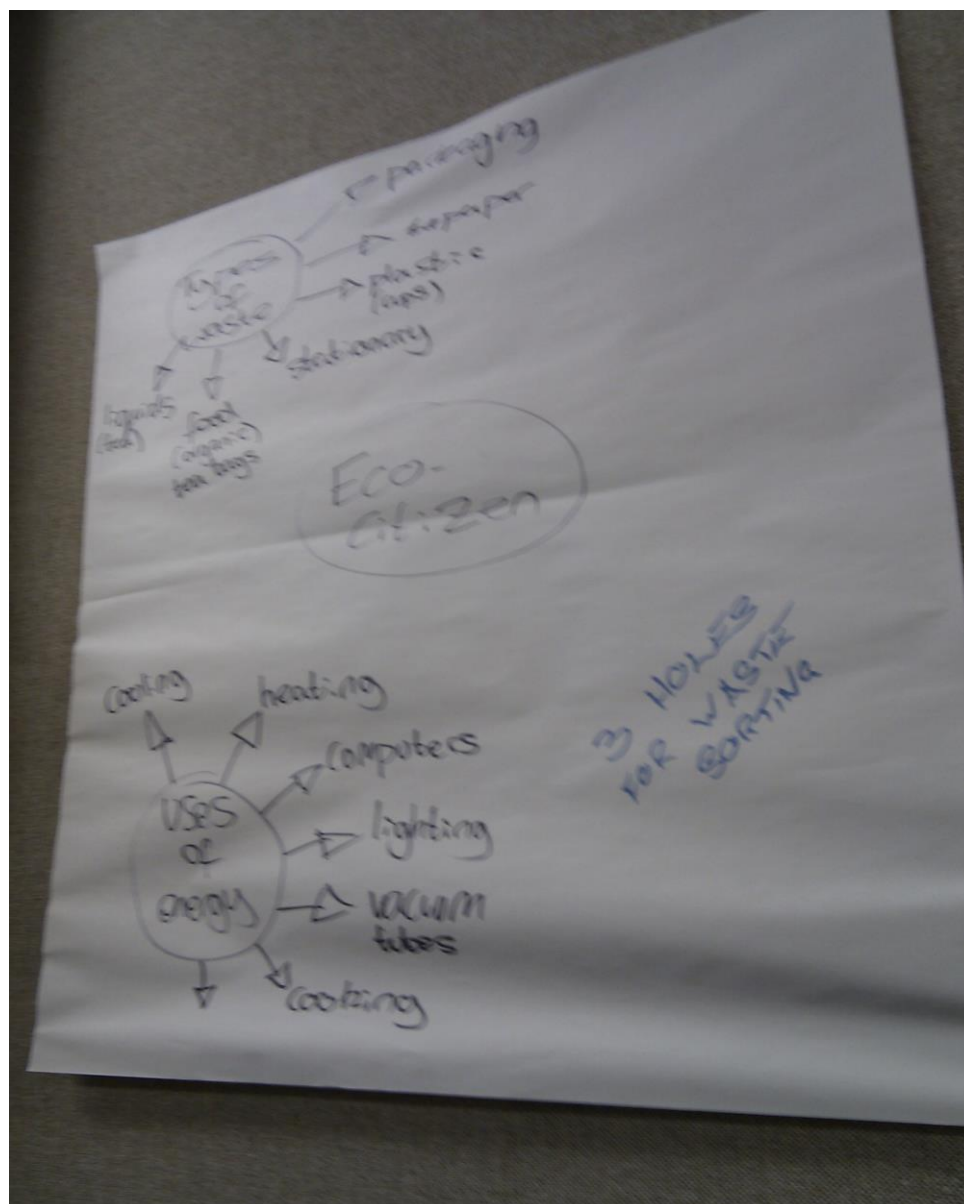


Figure 28: Analysing the Task Early on in the VDT Lifecycle (photographic data)

During the first (14:45-15:15) and second (15:45-16:30) VC meetings, whereby the two subgroups worked actually together, the team introduced themselves, established some communication patterns (e.g. exchanged emails and Skype usernames), identified each other's strengths so that they make use of them during the challenge, and agreed on the frequency with which the two subgroups would meet on the VC. From the first meeting, it became evident that the only University B participant that would take the liberty to speak on the VC was Frank (a pseudonym), as the rest would not be comfortable in English. Therefore, actual contact was not attained between the two subgroups, but rather between University A participants and Frank in all VC and other (Skype) meetings throughout the 24h.

Once they all seemed happy about the selected task, the University A subgroup attempted to extract as much information as possible from the University B subgroup with regard to what were the expectations. During the first VC meeting, one of the ESTIA24 sponsors intervened from the French site and outlined some of the expectations, e.g. whom the designed product should be used by. Questions to which she replied include: whether it would be a static or a dynamic object, as well as whether it would be centrally located in an open plan office or it would sit on each employee's desk. Overall, during this initial phase the participants tried to make sense of the design task and conducted two VC meetings and one Skype meeting. In Figure 28, I show how, on a traditional flipchart paper, the University A participants started jotting down their first ideas based on their initial understanding of the design task in their effort to start being collaboratively creative both within and beyond their subgroup.

Conceptual design phase – hours 15:15-05:20

The phases were not clearly separated from one another, and it was observed that the conceptual design phase began while the team were still trying to make sense of their task. Specifically, the first brainstorming session (Figure 29)—which was performed separately by the two subgroups—took place @ 15:15 and lasted for 30 minutes. During this brainstorming session, the two subgroups generated ideas as to what values their design would represent and what message(s) it was meant to communicate. As it is shown in Figure 29, this was to some extent an individual undertaking before the subgroup came together and discussed their findings.



Figure 29: Performing Brainstorming in the UK Site (photographic data)

During the second VC meeting (15:45-16:30), in addition to them introducing themselves further and organizing their next steps, the team went through the ideas they had generated in detail during their first brainstorming session (performed separately). They did so not only in speaking, but also by showing one another drawings of their concepts on flipchart papers. They realized that there was some overlap of ideas between the two subgroups but also expressed the willingness to borrow ideas from one another.

This chaotic emergence of ideas at the initial stages of my analysis was owed to latent elements of the idea identification process, such as: the challenge entailed when trying to recognize the individual who generated a certain idea (especially when the ideas came from manually produced written protocols, e.g. post-it notes; or when the participants had moved away from the area the video camera was capturing); the problem the idea would provide a solution to; the time an idea was generated; the communication medium (or absence thereof, if F2F) through which it was generated; and the activity the team was engaged in while it was generated.

Product development phase – hours 00:30-13:00

Circa 00:30—once the team completed their fourth VC meeting whereby they discussed some relatively finished ideas they had decided to take forward—the team began to design them on CAD and also, enhancing their concepts' features through Internet search, and prototyping them. Of the 197 ideas presented in the wordcloud (Figure 30), only 37 were generated during this phase (00:30-13:00). In particular, communication between the two subgroups (University A and Frank) during this phase concerned the additions of design features to objects, as for example with the addition of grass that would look like eco-friendly hair on a human-like object—an idea which was initiated by the University B subgroup and whose CAD modelling was performed by the University A subgroup.

During the last few hours, between 07:00 and 13:00 almost no design ideas were produced. In addition to them being tired, what took priority during these hours was the finalization of their ideas and their presentation which the University A subgroup managed to video-record and send to the University B subgroup so they include it in their actual presentation to the rest of the teams that partook in ESTIA24. The final presentation was liked by the organizers, but received no significant comments as per the designs and their creativity.

It follows that creativity during the 24h-long design process was high during the conceptual phase—which was found to overlap significantly with the previous and the later phases of the design process—but also at different moments. Based on the idea count, I produced a graph depicting the number of ideas that were generated at

different times during the 24h (Figure 31). Notably, of the 24h the team worked together, only four hours (as initially instructed) the team used synchronously together using the VC facility, 20 minutes via Skype, while use of Skype IM and email for communication purposes was minimal. YouTube and email were also minimally used for content exchange. Over the 24h, I developed the impression that though they developed a certain degree of familiarity that allowed the two subgroups to kid and laugh together, most of the work was completed separately by the two.

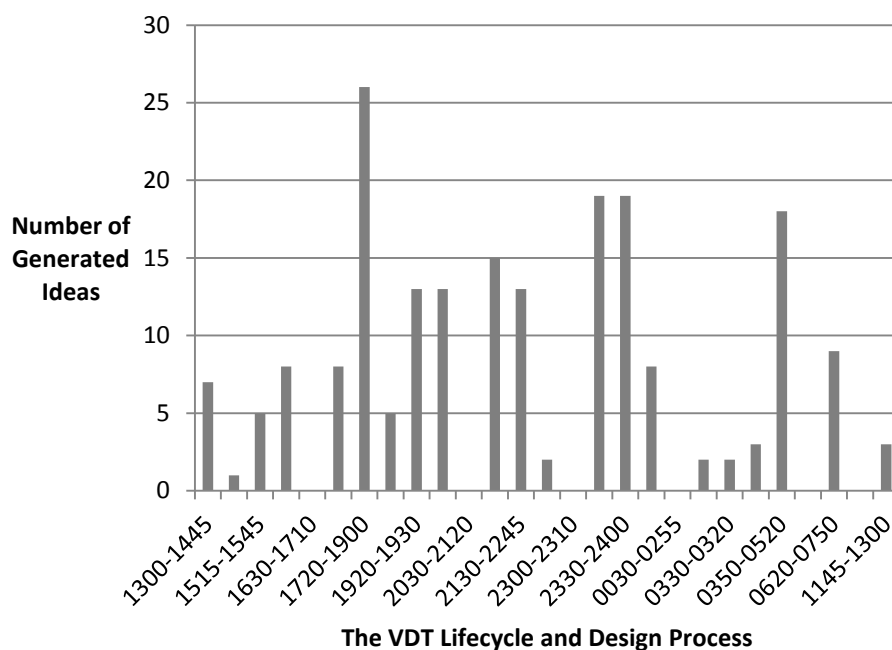


Figure 31: Creativity in the 24h-long VDT Lifecycle (after Excel in Appendix G)

Though a number of ideas made it to the end, below I discuss in the form of a short illustrative story how the idea of a mountain-shaped desk tidy was developed (Figure 32) in an effort to identify the role of the design process and activities as well as the role of virtuality. The reason I chose this specific idea is because it was the only one prototyped. The story reveals that said idea emerged mainly from one subgroup, demonstrating relative failure to collaborate and combine ideas around one specific concept.

7.5.2 Illustrative Story: A Mountain-shaped Desk Tidy

This idea was prototyped in the UK site. It concerned a static, abstractly shaped desk tidy made of recycled materials (e.g. used papers) which would sit on a desk to inform and constantly remind workers the need to recycle, whilst also serving as a stationery holder (e.g. clips, pencils) engaging its user(s) in frequent use.



Figure 32: A Mountain-shaped Desk Tidy (photographic data)

A first configuration of this object idea began to emerge early on in the design process—circa 17:20, approximately five hours upon commencement of ESTIA24—by the University A participants. I identified 38 data points across my diverse dataset referring to this idea, which involved several characteristics, features, and functions (e.g. object, fun, engagement, gadget, recycled art, reusability, motivation, education, pencil holder, reminder). While the core ideas that this object would communicate (e.g. motivation to recycle, education, encouragement) were all generated during the brainstorming stages of the design process in a F2F team environment within the University A subgroup, its shape and appearance was influenced significantly by Internet research the University A participants conducted

individually at different times (e.g. images of Voodoo pen displays, executive desk toys). In this case, virtuality only served in communicating the initial idea and its subsequent development and also in tracking its progress with the University B participants against the original time plan. The actual creativity as a process of generating ideas—which led to the development of one finished idea—was clearly performed by the University A subgroup in a F2F environment.

Though the above is about the only idea that came to fruition, other ideas emerged too, which were considered creative among the participants themselves (Figure 33).

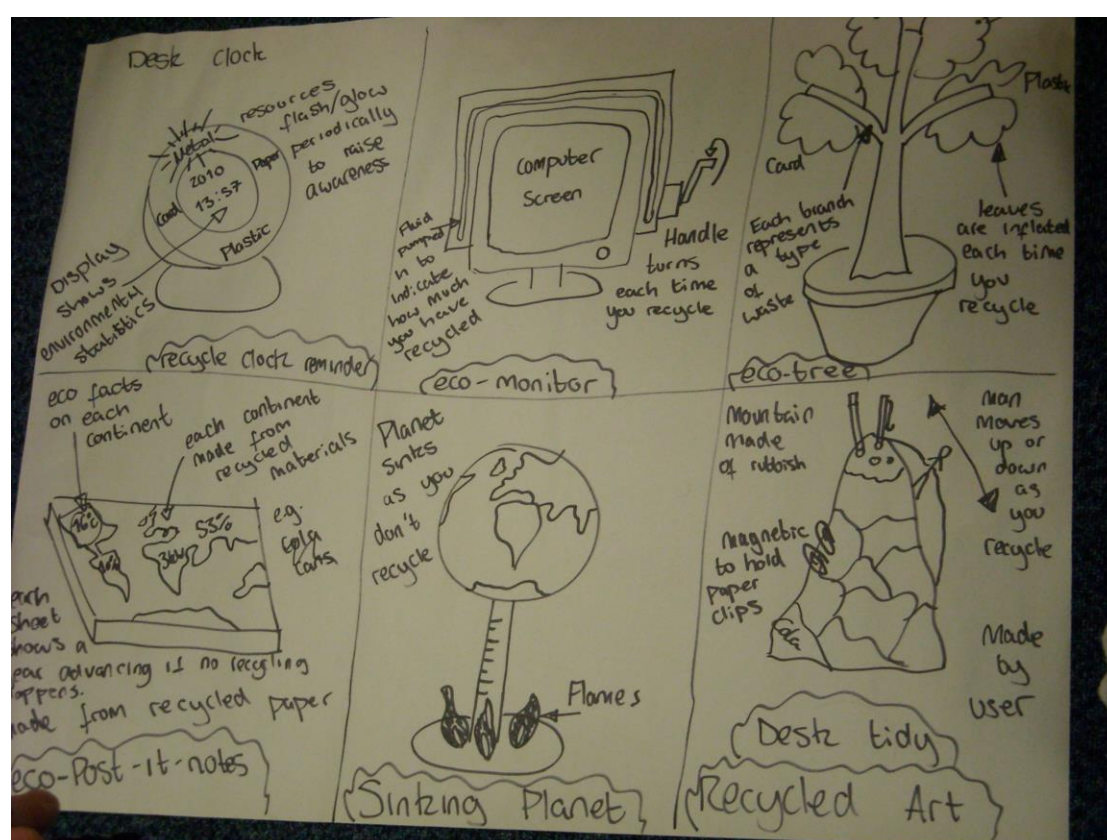


Figure 33: Six Ideas during the ESTIA24 from the UK Subgroup (photographic data)

Figure 33 is a photograph of the six main concept ideas the UK subgroup generated early on in the design process. All six were explained to the French subgroup during the second VC session. The sixth idea is the **mountain-shaped desk tidy**, described earlier, but evidently more ideas emerged. For example, Figure 34 is a representation of the **hourglass idea** which would be used to remind office workers of the time to recycle and was designed using CAD.

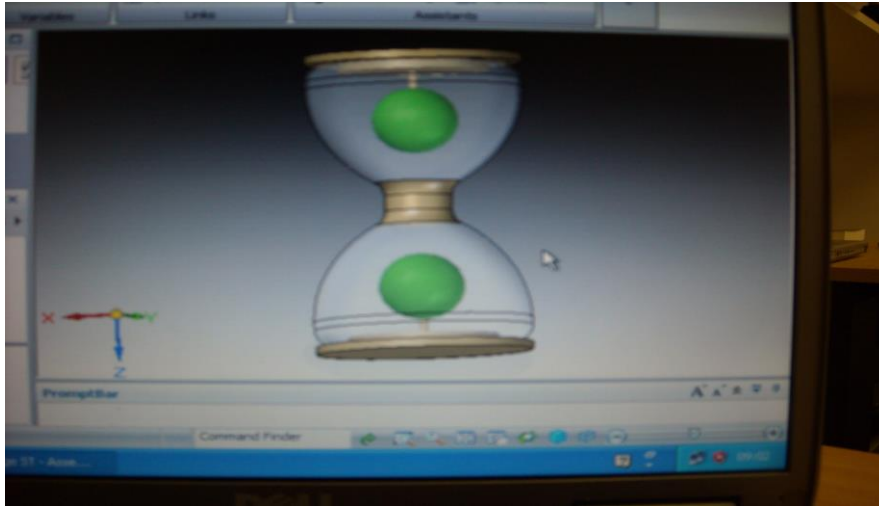


Figure 34: Hourglass Idea on CAD (photographic data)

Another idea that was substantially discussed within the team is one that emerged from the University B participants, suggesting that a friendly human-like bin could be used to remind office workers to recycle by throwing their recyclable items in it (Figure 35).



Figure 35: Post-it Bin Idea (photographic data)

The chapter continues by discussing that management issues, and their relationship with virtuality, found through the recorded observations and video analysis to influence VDT creativity.

7.5.3 Management Issues Influencing Creativity

Table 18: Management Issues Influencing Creativity in ESTIA24

Management Issue	Relationship with Virtuality	Action revealing the Issue	Illustrative Example
Communication	Language	Acting Out	The French subgroup thought of acting out how they wanted the object to act in order to communicate their idea to the University A subgroup.
	CMC	Actual Communication	It was not always easy to attain inter-subgroup communication owing to technical, quality and suitability issues. For example, <i>“I think we will try calling you on the VC, the quality is not so good”</i> (visual analysis extract)
Collaboration		Idea Communication	<i>“We even have a 3D printer so we prototype, we can make any shape and then print it and send it over to you [...] we are uploading it to YouTube, so we will send you the link once it’s done”</i> (visual analysis extract)
Work Organization	Temporary Character	Time Management	<i>“We will contact you again probably in 3 hours ... that gives us time to develop more ideas, and then we can do concepts and more ideas, and then meet again and see if we can do one thing together and get a general theme and we are not doing the same thing together”</i> (visual analysis extract)
	Boundaries	Lack of Visibility	<i>“Maybe we should let them talk first this time [...] Now that we see what we each have ... we will develop our ideas further and we will ring you back in two and a half hours and we should then be in a position to take things forward”</i> (visual analysis extract)
		Lack of Clarity	<i>“Do we want to make one object between us (the two subgroups) or two objects that work together”</i> (visual analysis extract)

The management issues found through visual and thematic analysis of my recorded observations to influence creativity were communication-, collaboration- and work organization-related, and relate to four aspects of virtuality: language, CMC, temporary character, boundaries (Table 18).

Especially at the early phases of the design process, when the team were trying to make sense of their task and generate design-related ideas, a noteworthy number of ideas were not related to design, but rather to management issues the team encountered. Table 18 encompasses the three types of management issues that were found to exert an influence on creativity, but is not inclusive of all the management issues the team were faced with during the 24h. For example, a number of management issues were not anyhow linked to creativity. Predominantly, these unrelated management issues manifested themselves once or twice and concerned how each subgroup would call themselves, what the team's name would be, and what ranking system they would use to filter their design ideas, among others. However, as they were not relevant to creativity, I did not consider these issues further. Instead, my analysis centres on the recurrent issues cited in Table 18 and considers their relationship with the unique characteristics of virtuality. While The latter contains limited illustrative examples of these issues, which highlight their nature and their relationship with virtuality, in what follows I discuss these issues in more depth.

Communication-related Issues

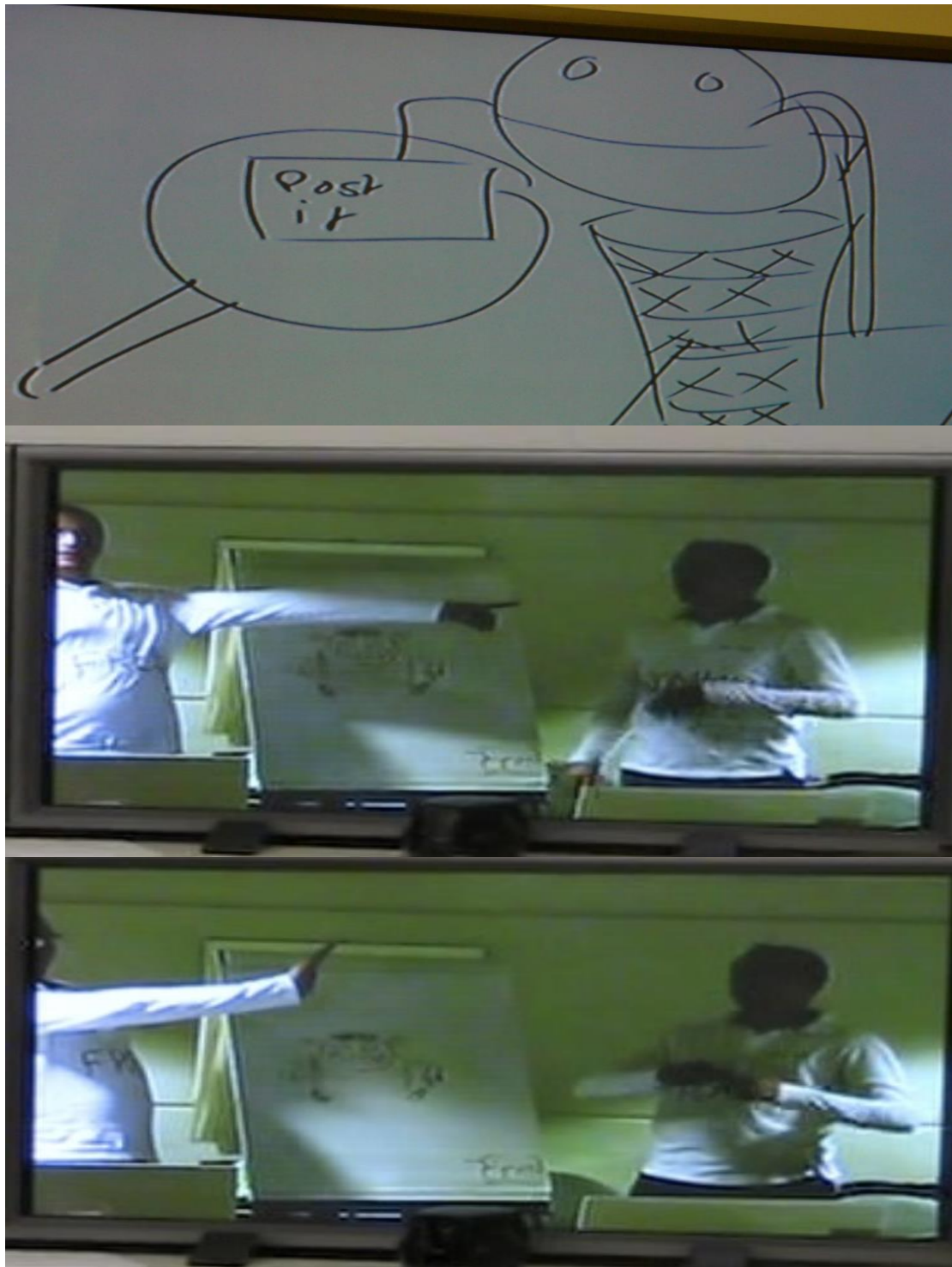


Figure 36: Acting-out Concept's Functions due to Language Issues (video data)

Communication-related issues were found to be linked to both the use of language as well as the use CMC. The team experienced language-related misunderstandings which influenced their creativity both positively and negatively. For example, early

on in the design process (first reference at 14:57), while the two subgroups were discussing on the VC possible concept ideas, the University B subgroup used the English word *dishes* to refer to *rubbish*, influenced by the French word *déchets* (pronounced similarly to *dishes*) which means *rubbish* and is a false synonym of the word *dishes*. This misunderstanding confused the University A participants and interrupted their creative process as they gathered that the University B participants were abruptly talking about another concept of theirs.

The misunderstanding was resolved when one of the University A participants intervened and pointed it out to all involved: *"I think you don't mean dishes, you mean rubbish"* (observation extract)—though the University B participants used both *dishes* and *rubbish* to refer to *rubbish* from that point on. However, language-related issues were not necessarily negative for the team's creativity; University B participants' lack of fluency in English led to an increase of creativity in terms of the manner in which they would communicate their concepts across the VC. For instance, once they realized circa 03:00 their human-like object's functions were not fully understood by the University A participants, they took the initiative to simulating on the VC how their object would interface with the user, in order for the University A participants to make sense of their concept. The initial drawing which was not fully understood by the University A participants, as well as the University B participants' initiative to simulate the interface between object and user is shown in three snapshot pictures I extracted from the videos in Figure 36.

Of likewise importance was the issue of actual communication, namely how they would speak to one another, that puzzled all participants numerous times throughout the virtual design process. Actual communication problems started early on, when the two subgroups were supposed to connect via Skype and attend the briefing presentation:

"Skype intro—mostly in French—not very successful—connection problems—different Skype accounts created—Skype crashing because of numerous users trying to connect—trying to find who the other half of the VDT are." (observation extract)

On the one hand, the constraint that was imposed on the time the VC would be available to them did not allow for constant use of the facility, while on the other hand, the alternatives the participants identified (e.g. Skype) could not afford the quality needed. The issue of quality over Skype was significantly intensified due to the aforementioned language issues. Overall, communication was found to be a management issue that mainly had a negative influence on the team's creativity, and which can be related to two known aspects of virtuality: language and CMC.

Collaboration-related Issues

Further to communication, inter-subgroup collaboration, and the relative failure thereof, was found to inhibit the team's creativity too. Over the 24h, the University A participants repeatedly expressed the concern that the two subgroups would wind up doing the same thing twice, suggesting failure in terms of collaboration between the two subgroups. Not only were they not sure what the other subgroup were doing over extended periods of time, but they were furthermore puzzled as to how they would overcome the *exchange of ideas* level of communication and turn it into actual collaboration. One idea Craig threw was to combine the two subgroups' strengths so that one subgroup would do what the other would not be able to. For example, the University B participants did not have CAD facilities so they passed some of their concepts to the University A participants who did the CAD for them. Similarly, YouTube proved a useful platform, at the latter stages of the 24h, in order for the University A participants to be virtually *present* at the final presentation of the team's work, which was to take place in the French site at the end of the 24h. Using a video camera, University A participants recorded a number of actual presentations of one of the concepts and sent them over to the University B participants for them to select which of the video presentations would be the most suitable one, attaining this way actual collaboration. The issue of collaboration was one that concerned the participants substantially as it was found to have a direct link to their creativity; while all participants were able to generate ideas within their subgroup, no ideas were generated at the team level. Common denominator across all collaboration-related issues the team faced was the use of CMC.

Work organization-related issues

Another management issue found to influence creativity was work organization. In trying to associate the issue of work organization with certain aspects of virtuality, I observed that the team's attempts to organize their work were made in their quest to accommodate the time limitation, and to overcome the *invisible* and the *ambiguous*. In other words, this management issue is related to the temporal character of virtuality in this case, as well as to the issue of new types of boundaries in virtual organizing. On the one hand, the limited character of the 24h urged the team to develop a desire for VC encounters at frequent intervals. Though, at first, this seemed reasonable enough, it was later proved, not only by me, but also by the University A participants themselves, that some of these meetings were interruptions to their creative process. On the other hand, it was not always clear to the University A participants what activity the University B participants were involved in. The invisible character of working as part of a VDT led the former to question whether their teammates had taken the task seriously and were capitalizing on the time they had between the VC meetings. In addition to this lack of visibility of what the other subgroup were engaged with, the task, or subtasks they themselves were assigning to one another, were not very clear. For instance, it was not until the second half of the 24h when the team agreed on whether both subgroups would take one concept idea to the end, or they would perform separate concept ideas individually in their subgroups with the aim of ending up with two or more finished ideas at the end of the 24h. The above description demonstrates that though the CMC brought together two distant subgroups that would be unable to collaborate on a common goal if technology was absent, thus breaking geographical boundaries, other boundaries were created, which prevented the team from being as creative as they could have potentially been.

These communication-, collaboration- and work organization-related management issues highlight that, from the numerous unique characteristics of virtuality found in the literature, and which will be discussed in greater depth in Chapter 9, Discussion, it is mainly language, CMC, the team's temporary character, and the emergence of boundaries that influenced VDT creativity. And though this influence was mainly

negative, not always allowing the team to express their creativity to the fullest, it also led to alternative ways of communicating their ideas creatively, as we saw for example with the case of the object-user interface acting-out performed by the University B subgroup. Notably, though such management issues (e.g. communication) exist in F2F environments too, the data from this study show that virtuality can exacerbate them, making the participants lose focus on their main task, and preventing them from expressing their creativity fully. It is likely that if they were all sitting in a F2F environment, these same issues would not have influenced their creativity to the same degree.

Further to these management issues influencing the team's creativity in the ESTIA24 virtual environment, my non-participant observations, coupled with the interview data, led to the identification of two factors influencing VDT creativity, which are discussed next.

7.5.4 Task and Individual: Core Factors Influencing VDT Creativity

In addition to the management issues, analysis of the video data hinted at two factors that, though unrelated to the team's virtuality, exerted considerable influence on the team's creativity. They are design task and individual and I discuss their role below. These findings are also supported by the analysis of the interview data. I provide a selection of verbatim quotes in the analysis that follows.

Design Task

All interviewees noted that their creativity was significantly reduced because of various aspects of the selected design task. I mentioned earlier that it was the participants themselves that voluntarily selected one out of 34 design briefs, based on their initial judgment of whether they could perform it well within the 24h. They later realized they had neither interpreted the task correctly nor was it one with which they could show their full potential as designers. Aspects of the design task that constituted it inappropriate as well as inhibiting to the team's creativity are its simplicity, the fact that it was not significantly engineering-related, and vagueness in terms of its requirements. In hindsight, the participants were succinct in their criticism of their own choice:

"I would have picked a different project [...] something more technically challenging, more mechanically based; we are all mechanical engineers, that's our interest, we look these sorts of challenges, something more interactive, moving parts with a process to it. An object is not our thing at all." (Ryan)

Disappointment was also evidenced by all interviewees insofar as the task selection is concerned. For example,

"I didn't like it at all, you don't ask engineers to design a little thing for your desk, I think it was the wrong brief I guess [...] we expected a complex mechanical system and then, they were: we want a sign to say RECYCLE. So [...] that constrained our design creativity." (Craig)

Evidently, the task required little mechanical knowledge and the University A participants' enthusiasm about accomplishing a design task that would challenge

them, would excite them, and would give them the opportunity to use their skills, dropped significantly when they came to understand that their selected task was more about producing something aesthetically pleasing than something mechanically challenging.

The University A participants were suddenly informed by the University B participants that despite its relative simplicity from a mechanical point of view, the task would have to satisfy several requirements. University A participants found these requirements contradictory, because

*“...It was very constrained, first **they wanted something which is low cost, very simple, and very effective, and that's fine, but you normally have one or two of them, you can't have all of them.** For example, you can have something which is quick and cheap, and not necessarily effective.”* (Dylan)

Overall, the data show that the design task was (a) mismatched to the University A participants' skills; (b) too simple for allowing for creativity; and (c) misinterpreted at the task selection phase due to barriers imposed by the virtual character of the challenge. This lack of understanding on the part of the University A participants' perspective change their mind and led to acknowledgement of their low creativity.

The Individual

The role played, and contribution made, by each individual differed significantly. It became evident from the early hours of the 24h who volunteered to take the lead in both subgroups. On the one hand, Frank became the one representing the University B participants; he was always the one to speak during the VC meetings, representing not only his own views and work done, but also the others' in his subgroup. On the other hand, Dylan emerged as a leader in the University A subgroup. He dealt with most VC speaking, though others took over at the later stages of the process, he made most propositions and work plan, and he was also very active in generating ideas and other aspects of the job, such as asking questions to get more information on a number of issues.

Engagement in the task was found to be unequal among the University A participants; the interviews revealed that some participants were unhappy with others' contribution:

*"... **their presence was of limited value**, one other person was really distracting, they had a lack of boundaries, they didn't know what was appropriate [...] they were fixated on certain technologies that didn't really apply [...] **there was another person who was muted**, he didn't really add a huge amount, but didn't take much away either, you set them on a task and they're happy to carry on with it."* (Dylan)

While my interviews with the University A participants show that most did not have a full understanding of the challenge they were involved in prior to its commencement, Dylan—the emerged leader of the UK subgroup—acquired substantial information by asking me about the challenge a few days before the challenge took place. Therefore, Dylan came into the challenge with an increased level of knowledge and understanding of it, compared to the others. He was also able to coordinate the subgroup relatively well by splitting the work not only justly, but also in a manner whereby everyone felt unforced to undertake a task, as the use of we in the quote below shows:

“We split the work quite easily. Sean and Dylan did the presentation, Ryan and I did the prototyping, Craig did a bit of CAD and a little bit of research. It was evenly split.”
(Henry)

On the contrary, Henry can be described as the *silent designer* over the course of the 24h. He was happy to undertake any tasks that were assigned to him, but did not really contribute to creativity much. This was acknowledged by others and by him:

“I wasn’t the most active member in that [...] I was tired [and I] just decided to go with the flow.” (Henry)

Given the intra-University A subgroup dynamics—and despite the differences in overall contribution, leadership style, and approach—the data show evidence that ideas, both ideas concerning features and elements, as well as finished and more complete ideas were generated by all five University A participants over the 24h.

In addition to the above, certain unique characteristics of virtuality were found to influence VDT creativity in this study. I present this analysis in the following section.

7.5.5 Creativity and the Unique Characteristics of Virtuality

Though it is virtuality, and specifically the use of CMC, what made this ESTIA24 challenge possible, it is also what raised a number of challenges that reduced or even inhibited the team's creativity. These emerged purely from the findings and were not *a priori* hypothesized, thus the discussion below does not capture all the characteristics that the literature on virtuality sees as relating to VTs. Below I discuss how the unique characteristics of virtuality that emerged in my analysis were found to influence the team's creativity and provide sample verbatim quotes.

Geographical Separation

An issue that came up recurrently in the interviews was that of geographical separation; not only between the two subgroups, but also between the UK subgroup and the ESTIA24 site itself. And interestingly, it was not clear to all University A participants *a priori* that the challenge would be a virtual one, whereby the team, of which they would form part, would be split into two geographically separated subgroups:

*"When I first signed up for it, I **didn't realize it was going to be a virtual thing**. I signed up because it was a 24h challenge and because it was going to be with a team from France. I thought it was going to be F2F, I hadn't thought about it much"* (Craig); *"What I had heard is we would work with a team over in France, **didn't realize it was virtual**"* (Henry).

What is possibly shown in the quotes above is that the participants may have not been ready to partake in a virtual challenge. On the one hand, geographical separation was found to prevent the two subgroups from collaborating and working together toward common goals. Instead, the extent to which the two subgroups worked jointly as one team was limited to the number of VC meetings they had, whereby—as my observations discussed earlier suggest—the aim for the two subgroups was to go through what they had accomplished and set forthcoming deadlines. This also unearths another issue that was found to inhibit the VDT's creativity—that of lack of coordination mechanisms; for example, the participants were given freedom as per when and how they would communicate and collaborate

and there were no instructions given by ESTIA24 to guide them on this. Therefore, geographical separation between the two subgroups meant failure to collaborate as they would have done in a physically collocated environment, and was found to influence the team's creativity in two ways. First, much of the idea generation and development process was missed:

*"... you come up with a solution, but **all the process you've gone through to arrive at that solution, you wouldn't actually share it**, and lots of the time that information is more viable, or just as viable as your final solution, because **they might have excluded something which we would have included.**"* (Dylan)

As the quote above suggests, the fact that the two subgroups spent much time apart with no VC meetings or other synchronous communication influenced creativity at the team level significantly, as half the team were absent as ideas were generated and developed. However, it has to be noted that ideas were generated at subgroup level. Second, being separated meant the two subgroups would often wind up either doing the same work twice, or working on unrelated tasks as their work developed:

*"... we'll meet again in two hours' time and **by then you might have gone off to a complete tangent**, and then you come back and you're like, oh I think we were doing this." (Craig)*

On the other hand, geographical separation between the University A subgroup and the ESTIA24 main site played a twofold role in the team's creativity overall. As the UK subgroup were distant to the main site where most of the teams were based (i.e. France), they felt there was no much pressure on them and they could therefore be more open to new ideas and more flexible in their approach to the design task. Geographical separation in this regard enhanced the University A subgroup's creativity. In contrast, the University B participants were a lot more conservative and did not generate as many ideas as the University A participants did. In the interviewees' words,

*"... **because we were isolated, we had this degree of separation we could be more courageous, and a lot more bold, in our approach and style.** And then when they*

*were standing in front of the crowd, they were a lot more conservative. Obviously their creativity was much more muted, because **they were being marked directly, we were being marked indirectly.***" (Dylan)

In addition, the interviewees considered that it was partially because of this separation why they remained focused during the 24h, they did not get any sleep (as opposed to the French subgroup), and they did not participate in any of the social events (e.g. large dinner) that were taking place in the French site for all teams based there. Being isolated in a silent university setting on a Friday evening with no other people around increased their motivation to get the work done quickly, creatively, and efficiently.

However, despite this positive influence on creativity, geographical separation between the UK subgroup and the main site led to the wrong task selection, per the University A participants interviewed. The interviewees expressed the view that they rushed into taking a decision as to which the design task would be unnecessarily quickly. As they argued, being in a different location to the one the ESTIA24 introduction was taking place during the first hour of the 24h challenge had as a result them only taking into consideration the written material supplied subsequently to the introduction. Therefore, geographical separation at that early stage of the challenge meant that the University A participants lost one whole dimension; the spoken aspect of the introduction whereby the design tasks were explained.

Computer-mediated Communication

CMC was what enabled the two subgroups to come together and form a VDT in the first place. However, the interviewees expressed mixed views about their use of CMC during the 24h and the manner in which it influenced their creativity. While all participants appreciated the value of CMC, they all expressed concerns about its pertinence for a creative design task. One of the most critical concerns raised by the interviewees was that CMC created an artificial working environment which did not allow creativity to take place in the same way as it would in a physically collocated environment. While, for example, technologies with low communication richness, such as email, were taken for granted as being inappropriate, because:

*“... you can’t just email every two minutes, yeh we’ve done that, because **it would be too distracting**”* (Craig);

and also synchronous Skype communication would fail, the participants used the VC as their main platform for collaboration purposes. However, this was not proved to be ideal for their creativity:

*“... **we had to take turns to talk** whereas **in reality when you have a conversation, people jump in all the time, you sketch, you go around [...]** turns became more like, about going through an agenda, going through, stating, what we had done, but then not really having a discussion [...] **it was always from this fixed position [...]** you could [not] see what they were looking at [...] they had one static camera and then they were zooming into the board, and we would miss all their facial expressions [...] a lot of the time you have like **a moment that comes to you very quickly and you either need to share it quickly or you can forget** what you were thinking.”* (Dylan)

Having a fixed position using a static video camera was found to be limiting for the participants’ creativity, as they missed much of the cues that this type of CMC was unable to communicate. This led them to take turns and often lose track and miss out on much of their instant creativity. Virtuality in this regard decreased visibility between the two subgroups and created boundaries which inhibited creativity.

In a similar vein, the University A participants considered that they lacked the necessary technologies that would be more pertinent for a design task. They realized so by making comparisons with previous experiences of theirs:

"[In a past project I participated in] we did morphological charts to refine the ideas, we built on each other's ideas which didn't happen as much between England and France. That was quite different, and creativity there was high, you could stick things around on the blackboard." (Sean)

Most creativity happened when the team worked F2F, not during virtual, inter-subgroup communication:

"Creativity kicked in, not when we communicated with the French, but when we worked [F2F] with pen and paper." (Henry)

Despite these difficulties, and the relative failure of CMC to enable and enhance the participants' creativity at the team level, the two subgroups did manage to build on each other's ideas to some extent. This was attained through the VC facility:

"We were showing them ideas like, one of my ideas, the time capsule, you flip it round, the sun goes up, and say if you don't recycle or put the rubbish somewhere then the earth is sinking, we didn't realize it would have been better to have one side half of it and the other side the other half. They had the ideas, you know when people look at your design and have more ideas, at the end they got it but it took like 10 minutes." (Henry)

The Cross-boundary Dimension

The virtuality literature suggests that VTs typically span national, cultural, educational/organizational, and other boundaries. In this study, the interview data posited a number of links between creativity and these aspects of virtuality. I discuss them below:

Crossing educational boundaries

Educational boundaries were the ones that influenced creativity the most, especially during the idea exchange and discussion phases:

*“... We came to get our idea across, which was more like a system, it was quite complex and difficult to explain, **it was more of a, not just a product, but a whole function behind the product.** Our culture is quite different to theirs in general. Informing people of waste, maybe they don't do that in France and maybe that's why they couldn't quite understand.” (Sean)*

While the quote above suggests a difference in understanding, arguably owed to the fact that the French subgroup came from a different educational background, a different discipline, a different university, and a different country, and from a different school of thought, the following quotes reveal that the design process itself, and the rationale behind it, may vary between the two educational systems; the French and the British:

*“... **They came up with actual products, 2-3 ideas which didn't really work very well,** I don't think they worked very well as a team, because they only had 1 idea and then they'd really stick with it and didn't let themselves branch out and think, sort of, outside of the box. This is what they showed us. It was done on the white presentation things. It was very limited, **I think it was 3 ideas, whereas we had, I don't know, probably 12 we worked with, but initially we had like 40 on post-it notes, which I think it's a very good way of doing it because it lets you think and work.** The other team went straight into: is this going to work? So there was no creative element because **they went straight into a product and not the elements of the product.**” (Sean)*

*"I think **your job as a designer, as an engineer, is to investigate the original problem**, and decide if that is actually the problem, or if something else is the problem. A lot of the times what you're told is the problem is not the problem."*
(Dylan)

Crossing conceptual boundaries

Though the data posit significant influence of boundaries in terms of the understanding of the concepts, it was not clear if these are associated with education or culture. For example, the story below demonstrates the attempts of the University A participants to prove to the University B participants that their idea (the mountain-shaped desk tidy described in 7.5.2) should aim to educate office staff about recycling, further to simply reminding them to recycle. Per the University A participants, it was not easy for the University B participants to understand why the object should also aim to educate, because this was not provisioned in the original brief:

*“... [regarding] the education behind [the mountain-shaped desk tidy idea], it **completely flocked when we tried to explain it to them, and we couldn't get it across**, and I don't know if that was [...] was cultural [...] we were going on about education stuff, a key element of recycling, it's not just reminding [office staff], it's telling them why is important in the first place, you have to get them to engage in the process, you have to teach them, so that they believe it themselves. As soon as you stop looking, enforcing, they are going to stop doing it. [The University B participants] seemed a lot more conservative in their approach, **they seemed to take on exactly what they were told to do**, because what they came up with, **they wanted to stick a lot more to the brief**, it didn't develop over the 24h period, it was very much like, oh we want something which is fun, that sits on the desk, and reminds people to recycle.” (Dylan)*

Crossing language boundaries

There is no doubt that the fact that this VDT brought together two subgroups who spoke different languages caused some confusion within the team. The role of language in creativity is an issue that was also posited in my own recorded observations and discussed earlier (in 7.5.3). The interviewees considered that language influenced their creativity in two ways: by reducing the elegance of describing ideas, and by making them lose track:

*“... for quality, **you have to sacrifice lots of stuff. I think the language barrier did account for half of it, for example elegance of describing**, they weren't able to, it wasn't their first [...] because you're conscious of [...] the language barriers **you have to speak much slower** and use less, simple language to describe it, so normally for me at least, **I go quickly through ideas, but then I had to slow down a lot.**” (Dylan)*

These findings demonstrate that the two subgroups were significantly heterogeneous, highlighting the multidimensional character of subgrouping in the case of ESTIA24. In particular, the two subgroups differed in numerous aspects, including educational background, language and culture. These differences raised significant boundaries inhibiting creativity at the team level, and were not easy to overcome. Interestingly, and further to issues of geographical distance between the two subgroups, cultural differences between the two subgroups were found to influence the participants' perceptions of this distance, as the extract below also shows:

“[UK subgroup] believe distance is not an actual problem; they think they would be more creative as a team if the other subgroup were in Scotland instead of France” (observation extract)

The findings from Study 2 are summarized in Table 19 below, where brief illustrations or examples are provided based on the earlier analysis. Categorization per major and minor enhancers and inhibitors is based on my interpretations of these factors influencing VDT creativity in ESTIA24.

Table 19: Factors Influencing VDT Creativity in ESTIA24

		Enhancers of Creativity		Inhibitors to Creativity	
		Major	Minor	Major	Minor
Virtuality	Boundaries			<p>Differences in education and culture generated boundaries that inhibited shared understanding of (a) VDT collaboration and (b) concepts and their roles, significance and rationale</p> <p>Boundaries in culture augmented the perceived distance between the two subgroups, positing lack of trust</p>	<p>Boundaries owed to education influenced the difference approaches taken toward VDT work</p>
	Language		<p>Lack of language fluency leading to different expressions of creativity: acting out a concept</p>	<p>Lack of language fluency making the participants lose track</p>	<p>Lack of language fluency leading to reduced elegance of describing ideas</p>

	Geographical Separation	<p>Geographical separation between University A and ESTIA24: lack of direct pressure by organizers leading to more creativity</p> <p>Geographical separation between University A and ESTIA24: absence from ESTIA24 social events and temptations helped the subgroup remain more focused</p>		<p>Geographical separation between the two subgroups: idea generation process being partially missed</p> <p>Geographical separation between the two subgroups: work duplication / working on unrelated tasks</p> <p>Geographical separation between University A and ESTIA24: led to the team selecting a design task they were not happy with</p>	
	CMC			<p>Synchronous CMC causing an artificial environment characterized by the need to take turns, fixed participant positions and lack of spontaneity</p> <p>Lack of pertinent ICTs for design (e.g. shared blackboard); inhibiting use of <i>pen and paper</i> techniques</p>	<p>Synchronous ICTs were either costly (i.e. VC) or of poor quality (i.e. Skype)</p> <p>Asynchronous ICTs were either distracting or time consuming (e.g. uploading videos on YouTube)</p> <p>Lack of CMC management and coordination mechanisms</p> <p>CMC reducing levels of visibility and clarity between subgroups</p>
	Subgrouping			<p>Multidimensional Subgrouping: Locational, Cultural, Linguistic, Educational</p>	

	Emotions				Perceptions of Distance: Heterogeneity and the multidimensional subgrouping augmented distance
Individual		Personal Attributes: Inquiring Mind High Motivation and Engagement Levels	Good Understanding of the Project Leadership Potential: Driving the Project Forward without Conflict	Lack of Team Spirit: Undertaking Tasks without Consulting with the rest of the VDT	Lack of Initiative: Being a Silent Designer
Task				Insufficient information on design task (a) different interpretations ; and (b) unclear expectations Design Task unrelated to the participants' expertise	Design Task Simplicity Design Task Vagueness Design Task Contradictions

7.6 Reflection on, and Strengths of, Study 2

Study 2 built on the lessons learned from Study 1 and provided important accounts of creativity in the VDT context, which I outline below:

First, by focusing on a single VDT, rather than six, which was the case in Study 1, which had a very short lifecycle (24h as opposed to five months), I was able to take a closer look into the creativity of the team, capture most of the participants' activity, and attain a deeper level of granularity in my analysis. This is a significant strength with added to my choice of ESTIA24 as a research setting for this research. The VDT studied here shared some common characteristics (e.g. it was a global VDT and temporary in character, it took place in an educational setting, subgroups were formed within it) and, importantly, the same analytical approach was adopted (though this was revisited to overcome weaknesses of Study 1). The findings from Study 2 continue to inform similar relevant literature on VTs—e.g. based on Panteli's (2004b) temporary and global dimensions of VTs—as those of Study 1 and also provide evidence of how creativity is influenced in a type of VDT that is close to what the literature describes as a PDT, whose members are distributed between two or more physically separated subgroups (Ocker *et al.*, 2009a; Ocker *et al.*, 2009b).

Second, building on the impression of how creativity occurs during the VDT lifecycle offered by Study 1, I followed a more robust methodological approach and performed a count of design ideas generated during the lifecycle of the team, based on my own observations and video analysis of the participants' interactions. Importantly, I positioned the generated ideas in the VDT lifecycle (Figure 31), which contributes an alternative, more robust impression of where creativity is positioned within a VDT lifecycle, contributing to relevant literature on VT lifecycles (e.g. Hertel *et al.*, 2005). This is the first study to attempt to position creativity within the VDT lifecycle by this approach, which is of critical importance in order to understand how creativity is influenced in the context of VDTs.

Third, the findings of Study 2 are based not only on interview data but also on data emerging from observations and video analysis. Observations took place in Study 1 too, but what differed in Study 2 is that observations were conducted throughout

the project, capturing most of the VDT's activity, and they were also used to guide video analysis, which had not been done in the previous study. As such—and consistent with literature on qualitative research arguing for the use of multiple data collection methods for purposes of completeness (and not for triangulation) (Tobin and Begley, 2004)—my analysis of Study 2 was more comprehensive in that it entailed different findings emerging from the different types of datasets.

Fourth, though my analysis led to the elicitation of factors that are not necessarily or strictly related to the virtuality of the VDT under investigation here (e.g. task, individual) reinforcing prior literature on creativity and design, the main strength, and theoretical contribution, of this study lies in the elucidation of the relationship between creativity and a set of unique characteristics of virtuality (e.g. CMC, boundaries) that emerged in my analysis (discussed in 7.5.5). Further, this study also suggests that management issues that came up in the video analysis relate to certain characteristics of virtuality (discussed in 7.5.3), which again form part of unique characteristics of virtuality found in the VT literature.

7.7 Onward

In the last two chapters I have presented two case studies that advance our understanding of creativity in the VDT context by positioning, through different methods, creativity within the VDT lifecycle, eliciting factors influencing creativity in the VDT context, and drawing connections between creativity and the unique characteristics of virtuality, which begin to explain how creativity is influenced within this context. In the following chapter, I present a comparative case study which extends these findings by adopting a similar methodological approach with a team in a different context, the industrial.

Chapter 8: Case Study 3—A Comparative Case Study in Industry

In this chapter, I present a comparative case study, which I pursued in an industrial context in my quest to discern factors influencing creativity between the Face-to-Face (F2F) and the Virtual Design Team (VDT) context, through comparison of two projects, with the aim of further advancing understanding of the relationship between creativity and virtuality. The study draws on a single team which came together for the purposes of this research, and worked on two separate design tasks: one that was completed in a F2F environment, and one that was completed virtually. I begin the chapter by presenting the research site and I thereafter explain its suitability, introduce the team under investigation, discuss the data collection and analysis processes, and present the analysis and findings of the two projects. I close the chapter by bringing the findings from the two components together and by reflecting on this case study overall before I proceed to Chapter 9, Discussion.

8.1 The Research Site

8.1.1 Alpha—The Organization

Contrary to Studies 1 and 2, which were conducted in educational environments, and in which the participants were students, in Study 3 I used a small design practice, called Alpha (a pseudonym), situated in the southwest of England, as a research site. Alpha is a Small- and Medium-sized Enterprise (SME) which has technically existed since 1998 and was formally established as a company in 2007. It has two directors, and is split between two shareholders. Per publically available information online, Alpha's net worth is £3,545, their total assets are £50,719 and their total liabilities £53,642. It employs a few workers and for the purpose of this study two additional members were temporarily employed, one of whom was offered employment on completion of the two projects. Per its owner, manager and

study participant, Geoff, the practice is about design and design thinking and there is no specialization in terms of a specific category of products or industry:

*“... there is no common thread in terms of productive categories. **It's design thinking, it's being able to take a problem and find a solution for it, or start from just an analysis of what they do, look for problems and opportunities [...] well the way we work is either we solve problems or we look for opportunities.** So sometimes you're given a problem to start with and you have to find things that they can do that better, but **the thread behind all of it is actually using design thinking to come up with new ways of doing things, systems or products.** So there is no common thread in terms of the categories.”* (Geoff, F2F interview)

Creativity is therefore an inherent facet of Alpha's philosophy, since it entails coming up with new ways, new systems, and new products. I now turn to explain why Alpha is suitable at this stage of my research.

8.1.2 Alpha's Suitability

Alpha is a pertinent research site for this stage of my research for the following reasons:

First, Alpha constitutes an industrial context. As a design practice, Alpha is a representative research setting for research purposes (Cash *et al.*, 2014), and, being an SME, it is representative of the vast majority of enterprises within the UK (White, 2011). Having pursued two case studies in educational contexts, it became necessary to research creativity in industrial VDTs whereby the participants would be professionals—not students. Selecting Alpha instead of a university not only removes the pedagogical limitation from the VDT context under investigation—which may exert significant influence on creativity—but it also offers a platform for the study of organizational aspects of creativity, which I have thus far been unable to examine. The use of an industrial context insures that the dynamics of an industrial environment, such as adequate experience and expertise, will be in place and any relationship between them and creativity and virtuality will be scrutinized. Likewise importantly, studying VDT creativity in an industrial context boosts the value of this

research as it warrants implications for practitioners; therefore, the findings from this study can be used to improve industrial practice.

Second, the issue of access played a large part in my decision to select Alpha at this stage. Indeed, access to an organization that would allow me to be present, observe, and/or record their work was limited. Therefore, I took my lead supervisor's suggestion to use one of her industrial contacts, owner and manager of the selected design practice, who agreed I could use his design practice for my research.

Third, flexibility was important. Alpha was flexible enough to enable the development of a quasi-artificial scenario whereby the team conditions would be such to suit the aims of my research at this stage. Geoff agreed to lead, and partake in, two separate, but highly similar and comparable, projects, each of which would last two working weeks, and would comprise the same participants. Importantly, it was also agreed that one project would be conducted in a F2F environment with minimal (if any) virtual communication, and the second project would be completely virtual with minimal (if any) F2F communication. The timing and location of the project also suited my research project.

8.2 The Team under Investigation

The team comprised three members. One was the owner and manager of the design practice wherein the two projects took place. The other two were recent graduates who were temporarily recruited for the purposes of this study. The two recent graduates were not paid by Alpha, but were sponsored by the University of Bath for their employment. Below I present the three participants in the study.

In presenting the three participants, I altered their real names to protect their anonymity, keeping the first initial alike to reduce confusion while I was performing the analysis. I will therefore use the pseudonyms Geoff, Patrick and Steve to refer to the three participants (Table 20).

Table 20: Presentation of the Industrial Team Participants

Name	Nationality / Mother Tongue	Birthplace	Gender	Age*	Education	Industrial Experience	Main Strengths	Experience working Virtually
Geoff	British / English	UK	M**	45	MEng Mechanical Engineering, MSc Design Engineering	22 years of industrial experience	Valuable industrial experience	Y***
Patrick	British / English	UK	M	23	MEng Mechanical Engineering with Specialist Design	1-year industrial placement, 3-month industrial placement	Visual idea articulation Organizational skills	Y
Steve	British / English	UK	M	23	MEng Mechanical Engineering with Innovation Design	1-year industrial placement	Computer-Aided Design (CAD)'ing Rough sketching	N**

Age: as of summer 2011; **M = male; *Y = yes, N = no*

Geoff is Alpha's owner and manager and acted as the leader of the two projects that were organized for this study. Geoff is an experienced designer who was trained as a mechanical engineer at Loughborough University with the support of a scholarship

by Rolls-Royce Motor Cars. He also obtained a joined master's degree in design engineering from the Royal College of Arts and Imperial College London. Prior to initiating his own design practice in 1998, Geoff held various design-related roles at such prominent companies as Rolls-Royce, Dyson Ltd and Triumph Motorcycles Ltd. As a designer, he has had to work virtually numerous times on a global scale, having been faced with the challenges of working in different time zones and with different cultures. Therefore, Geoff is experienced working virtually.

Patrick and Steve are the two recent graduates, here and after known as junior participants, who studied mechanical engineering with innovation/specialist design at the University of Bath. They completed their studies just before the present study took place—at the beginning of the summer of 2011.

Patrick has had two industrial placements during his studies with two renowned engineering consultancies: a yearlong placement with Arup; and a three-month long with Buro Happold SMART Solutions. While during his former placement Patrick did not have any virtual collaboration with his colleagues, during his latter placement he worked as part of global VDT between the UK and Spain. His virtual experience during that placement involved (a) weekly meetings through a Video-Conferencing (VC) system and (b) emailing. Therefore, Patrick has had some experience using both synchronous and asynchronous Information and Communication Technologies (ICTs) for professional purposes.

Steve's industrial experience is limited to one yearlong industrial placement as part of his degree with 3P Innovation Ltd. The company projects itself as *"a successful engineering company with a reputation for providing innovative solutions to major pharmaceutical, medical and fast moving consumer goods companies"* (3P Innovation website). While there, Steve developed expertise in Computer-Aided Design (CAD) work and in testing products in a laboratory. Given that this type of job was to a high degree individual, Steve did not have to collaborate virtually with other colleagues during his industrial placement.

It follows from the above that there exist both similarities and differences among the three participants in the study. High degree of homogeneity is posited among all three in terms of nationality, mother tongue, gender and education; while the most marked differences lie in the aspects of age and level and type of experience, as Geoff is a senior designer, and Patrick and Steve recent graduates with limited work experience, and limited or no virtual work experience. Following the presentation of the participants in the study, I now move onto a presentation of the two components of the study and a brief discussion of the team-level characteristics of each project.

8.2.1 The Face-to-Face Project

The F2F project commenced on Monday 13 June 2011 (Day 1) and ended on Friday 24 June 2011 (Day 10), totalling two working weeks. The design task for this project was **a man overboard recovery device**:

“... to design a system for getting people back on a boat once they have been overboard, so a safety lifting system.” (Patrick, F2F interview)

Though the participants started the project from scratch, and Geoff encouraged the two junior participants to think widely and generate a large number of ideas, Geoff had already been given a patent for the customer’s idea, which ultimately restricted the participants’ solution space and creativity. The participants worked in a F2F environment in the design practice and made minimal use of emails each time Geoff was unexpectedly absent working on other projects. They used a large number of flipchart papers which they hung on the wall, as well as coloured markers and other materials.

8.2.2 The Virtual Project

The virtual project commenced on Monday 18 July 2011 (Day 11) and ended on Friday 29 July 2011 (Day 20), totalling two working weeks. The participants were based at three different locations within the UK, with the exception of Geoff who also spent time overseas for work; therefore, during the virtual project the participants did not meet F2F.

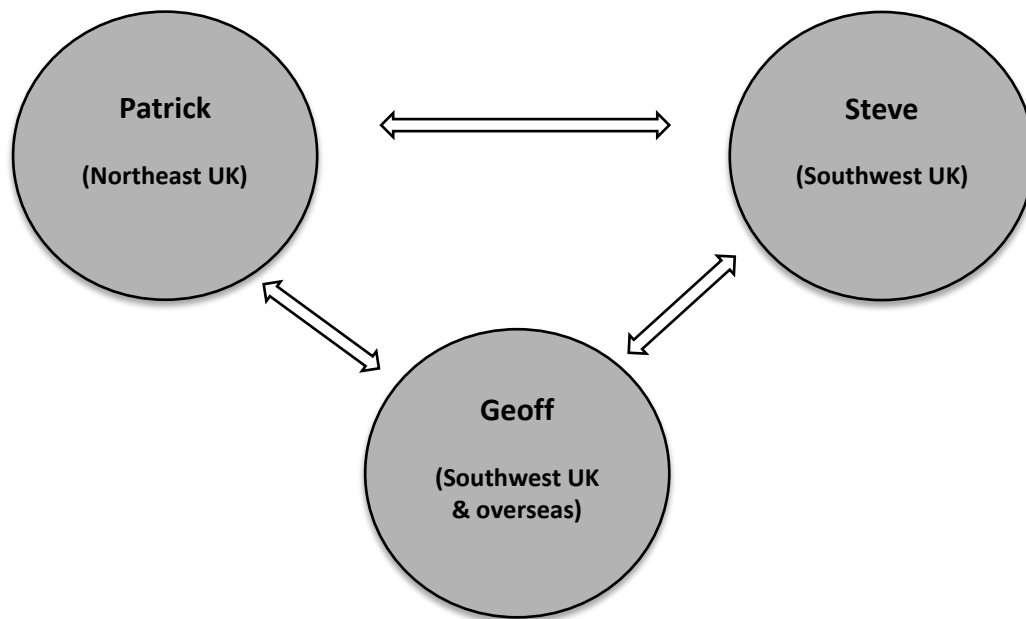


Figure 37: Geographical Dispersion in the Industrial VDT

The Design Task

The design task for this project was to design a **double-glazing system for period sash windows**. Geoff emailed Steve and Patrick the design brief at the kick-off of the project in the morning of Day 11 and followed it up with a Skype call:

“Window Sealing Project

This project is looking to develop an idea concerning double-glazing for period sash windows, of the type typically found in buildings in cities like Bath.

These windows are invariably made of timber and due to their age are usually poor at keeping heat in and drafts out. In addition they also suffer from condensation where humidity inside the building will condense on the cold window and form drips and puddles which is unsightly and can cause the timber to rot.

In many instances old timber windows have been replaced with more modern UPVC double glazed units. On the positive side these are maintenance free, highly insulated, and much more secure. On the downside they are often completely out of character with the rest of the building, and are expensive and disruptive to fit.

We are looking to develop a form of secondary glazing that will retrofit to period sash windows. This will improve their thermal performance, eliminate condensation, and retain the period feel of the building.

The solution must take into account the fact that the window frames on older windows can be distorted, i.e. not square, and that there are many different timber sections that the insulation must attach to.

There are a number of systems available on the market that can add secondary glazing but they are very expensive. The solution sought must focus on the ease of implementation, and ideally will facilitate the setting up of a business to carry out this work.

The output of this project will be the design of a system, both the glazing panel and the means by which it can be fitted to any window quickly and efficiently.

Geoff.”

(VDT email attachment, Geoff Day 11)

Methods of Communication

The participants were free to use methods of communication of their choice for the virtual project. They ultimately employed a number of ICTs with varying degrees of synchronicity to accomplish the design task. Though all three initially expressed the willingness, and made an attempt, to use group video calls, they did not end up finding an ICT that suited them. On the one hand, Skype Video Calls only worked between two parties, as Skype Premium was needed for Group (3-way) Video Call and Geoff was not willing to spend money on Skype. On the other hand, Google+ Hangouts did not seem to work owing to technical issues. Therefore, the participants' synchronous communication at the team level was primarily achieved via Voice-over-IP, specifically Skype Group Calls with no video involved. Secondly, the two junior participants used Skype Instant Messaging (IM) to coordinate themselves and socialize. A number of emails were also exchanged, while most of the work was done on Prezi—a modern and dynamic presentation program that allows one to share their work with others. Prezi was used as a collaboration platform, not as a presentation program that is its primary purpose, and allowed the

team to organize their work and share their ideas throughout the project. In Figure 38, it is shown how the team started organizing their ideas into broad theme categories (e.g. ideas about possible materials to be used for their product). The team conducted no F2F meetings throughout the project.

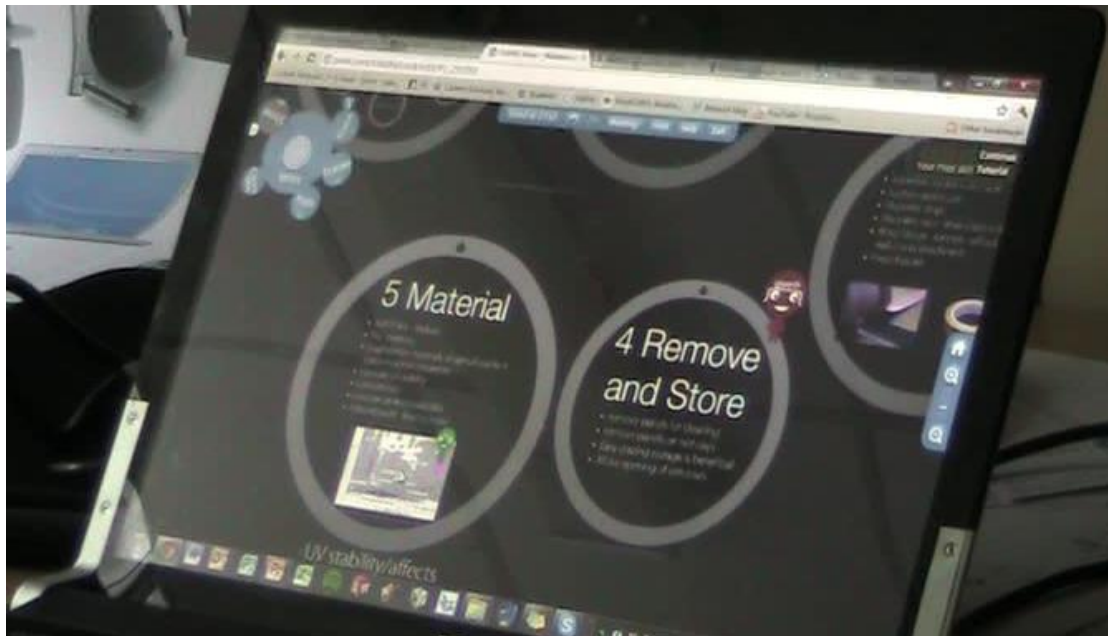


Figure 38: VDT Collaboratively Organizing Work on Prezi (photographic Data)

Having presented the participants in this comparative case study, as well as the two projects that were studied, I now proceed to discuss the data collection and analysis processes.

8.3 Data Collection Process

For this comparative study, I employed multiple data collection methods following the approach I developed for Study 2.

Table 21: Detailed Data Collection Table

Data Source	Data Type	Collection Instrument	No.	Length
F2F Component				
Video Recordings	F2F communication	Video camera	18 sessions	966 mins (~ 16 hours)
	CAD Work	Video camera	7 sessions	300 mins
Design Outputs	Participant logbooks' notes and drawings	Manual Coll. & Photocopying	2 logbooks	61 pages
	Flipchart, post-it notes & physical drawings	Collected electronically	1 e-document	128 pages
Interview Data	Individual interviews	Voice-recorder	3	139 mins / 18 pages
Virtual Component				
Video Recordings	Voice-over-IP (predominantly Skype Voice Calls)	Video camera and/or Panopto	76 sessions	2,365 mins (~ 40 hours)
Design and Communication Outputs	Skype IM	Forwarded	10 daily digests	21 pages
	Emails	Carbon copied	5 Emails	Insignificant
	Participant logbooks' notes and drawings	Manual Coll. & Photocopying	2 logbooks	81 pages
Interview Data	Individual Interviews	Voice-recorder	3	118 mins / 26 pages

For the F2F component, I recorded the participants' interactions when they worked as a team of three, and occasionally when two of the participants worked

collaboratively as a dyad to discuss their progress and steps forward. My aim was to capture the participants' interactions when they worked as a team of three, in line with my unit of analysis (i.e. the team). However, other priorities prevented the team from working as a team of three. These conditions, when one or more members may become unavailable during a team's lifecycle are realistic and often posited in industrial practice.. Some of the meetings were observed following a non-participant observation approach, similarly to Study 2. The manual video camera used to capture the team's interactions was operated either by me or by the team participants when I was absent. They were instructed not to miss any communication they had as a team. I cannot claim that all interactions were captured, but the obtained data provided some useful accounts of creativity in a F2F team environment. Further to team interactions, a number of hours of CAD work were captured. Table 21 above outlines the details of the collected data for this study. In addition to the video recordings, one junior participant's logbook was collected after the project had ended, and approximately 100 flipchart papers produced by the team when working together were collected in an electronic format at a later stage.

Lastly, the three participants were interviewed individually immediately once the F2F project came to end. Interviews were conducted in a friendly manner at Alpha (Geoff) and in a meeting room at the University of Bath (Patrick and Steve). Interviews lasted 47 minutes on average. At the interviews at that stage I sought to obtain both a formal introduction and background information of each participant, as well as their reflection on the F2F project. The interviews were digitally recorded and were semi-structured in nature. They urged the participants to:

- Give background information of themselves (educational and other details);
- Describe any similar (work or other) experiences they have had;
- Discuss the design process of the project and identify creative moments;
- Give me examples of creativity at the team level based on this project;
- Rate creativity as idea generation on a daily basis; and
- Provide comments they felt that were related to the creativity of the project.

Through these informal discussions during the interviews, I looked for evidence around the factors influencing creativity in this project.

For the virtual component, I employed a similar approach to capture the team's virtual collaborations. I used mixed instruments: (a) a manual video camera capturing which was located in a shared office where one of the participants worked from for most of the virtual project; and (b) Panopto—a software program used to capture screen activity and audio. The use of Panopto proved particularly useful because it enabled me to look at their activities (e.g. going through their work using a presentation software called Prezi) while talking to one another using Voice-over-IP technologies (i.e. Skype Group Calls). The aforementioned video material I gathered from the team's virtual collaborations over the two weeks of the virtual project resulted in approximately 40 hours of video. Further, I was carbon copied on all emails exchanged among the three participants, while their Skype IM communications, work on Prezi and other documentation were put together in a Dropbox folder and sent to me. Details of these data are provided in the second part of Table 21.

On completion of the project, the three participants were interviewed again individually to reflect on their experience of accomplishing a design task virtually. I interviewed Geoff in his office, as previously, Patrick over Skype as he was away, and Steve in a meeting at the University of Bath, as previously. In the interviews at that stage, lasting on average 39 minutes each, I asked them to:

- Discuss the design process of the project and identify creative moments;
- Give me examples of creativity at the team level based on this project;
- Reflect on their overall experience of working virtually;
- Provide their views on creativity with regard to virtuality;
- Compare and contrast the two projects with regard to creativity; and
- Provide comments they felt that were related to the creativity of the project.

8.4 Data Analysis Process

The collected data were analysed in a similar manner as in the previous studies, and in line with the aims of the thesis. In what follows, I explain how the different types of data were analysed.

8.4.1 Analysis of Interview Data

Thematic analysis served as the analytical approach for the interview data, involving both open and axial coding. Contrary to Study 2, in which I analysed the interview data once the rest of the collected material had been analysed, in an effort to mitigate the interviewees' bias, in this study, analysis of the interview data preceded the visual analysis in my effort to understand the video data better.

Once the six interviews from the two components of the study (F2F and virtual) were transcribed, I printed out the transcripts (44 pages of raw data in total), read the transcripts several times, and performed open coding manually. At that stage of the analysis, I coded large parts of the narrative while trying to remain detached from my knowledge of the literature and the findings of Studies 1 and 2; and open to new themes that could emerge from the raw data. Manual open coding involved circling, highlighting and scribbling through parts of the narrative, which I found to be associated with the creativity (for both components) and virtuality (for the virtual component) of the project(s). Therefore, the open codes that were generated at that stage were not influenced by the literature or previous empirical work, but are based on my interpretations of the interviewees' perceptions of the creativity (for both components) and virtuality (for the virtual component) of the two projects. Example open codes include issues of absence, leadership and freedom (F2F component); and artificiality, high autonomy and low synchronicity (virtual component).

I later organized the open codes together using QSR NVivo 9 and performed axial coding. NVivo helped me group them together in larger categories based on patterns that cropped up recurrently. The issue of technology constitutes an example of flat axial coding, as it was found to be associated with: technology selection and work organization; technology failure and collaboration problems; and technology and

visibility; and technology and communication speed; thus, being a theme with three types of labels, or a code with three sub-codes. Axial coding was also informed by relevant literature on virtuality (e.g. geographical separation) and creativity (e.g. organizational influences on creativity). The axial codes generated are presented in the 8.5 Analysis and Findings section later. The findings that emerged from this analysis are significant because:

- They increased my understanding of other types of collected data;
- They contributed useful information that was not captured by other data collection methods (e.g. observations, video data);
- They mitigated some level of bias emanating from my own observations and understanding of the two projects; and
- They provided an improved understanding of the relationship between creativity and virtuality in the selected organizational context.

8.4.2 Analysis of Video Recordings and Communication Outputs

I watched the produced videos of the team working together, both in the F2F and the virtual project, a number of times in order to familiarize myself with, and increase my understanding of, the two projects and the activities the team engaged in. Of the approximately 56 hours of video recordings for both projects, which included both individual activities and several communications in dyads (predominantly between the two junior participants) and also at the team level, I focused in particular on the communications between the participants (approximately 26 hours of videos). Based on these data, I developed a description of the process the team underwent in both projects. Most importantly, this visual analysis had a twofold aim: (a) to position creativity within the team lifecycle (for the virtual component), and (b) to elicit management issues influencing creativity and understand their relationship with virtuality. Concerning the first aim, I manually identified ideas that the team generated and inserted them into an Excel spreadsheet. All identified ideas were coded in red colour and all management issues were coded in blue in my manual visual analysis. Concerning the second aim, and contrary to the previous case studies (i.e. Study 2 in which the aim was purely to identify management issues influencing creativity in the VDT studied with no comparisons between that and a F2F team), conducting this visual analysis in Study 3 helped me discern between factors influencing creativity in F2F environments, those that are transferable from F2F to virtual environments, and those that are unique to the team's virtuality, pursuing thereby an improved understanding of creativity within the VDT context. The issues that emerged as influencing creativity were subsequently analysed thematically, along with issues identified in other datasets, i.e. the VDT's written communication outputs (i.e. Skype IM and email). These were inserted into NVivo 9 and were analysed in a similar fashion as the interview data, which I discussed in the previous section. Next, I present the analysis and findings of Study 3.

8.5 Analysis and Findings

I divide the findings of my analysis into three sections and I begin by presenting the findings from the F2F component.

8.5.1 The F2F Project: A Man Overboard Recovery Device

I commence the analysis by providing a chronological description of the design team activities.

The F2F Design Process and Team Lifecycle

Days 1, 2 and 3 were the days when most of the ideas were generated. Teamwork commenced in the morning of Day 1 with all three sitting in the same room. Geoff informed the junior participants about the design task and they, in turn, started to ask questions in order to gain a better understanding of the project. The three sat together for a few of hours, they brainstormed together and made use of flipchart papers and post it notes that they starting hanging on the wall of that room.

The team broke the design task down to four functions that the device should offer when someone falls overboard: (a) keeping them within eyesight; (b) securing them; (c) lifting them; and (d) getting them back on board. They used these design problems as a platform for idea generation.

Through research and discussion around these areas the team managed to find a design solution that was close to what the client wanted by the end of Day 4. Days 3 and 4 were used to improve and make the selection of the right concepts from the ones that had been generated during Days 1 and 2. On Day 4, specifically, the team with the use of materials started to develop a plastic model of how their system would look like. This was important for their creativity, as developing an actual model for it gave rise to a number of problems that the team had not considered previously. For example, the actual model was a lot bigger in size from what it was supposed to be. By the end of Day 5 the team had produced a plastic model of their selected idea, which was then taken to the client on Day 6.

Between Days 6 and 10 (second week) the two junior participants worked more as a dyad and less as an actual three-member team, due do Geoff's unexpected

absences. Early that week (Days 6 and 7) the junior participants did some research regarding their design's aesthetic aspect and suitable materials from other products, which they could use for their system, and they finalized their CAD prototypes which were sent electronically to Geoff for feedback at the end of Day 8. On Day 9 they received Geoff's feedback, improved their design and CAD and on Day 10 (last day of the project) they made improvements on the actual plastic model as well to check issues of geometry and practicality.

Following this description of the activities performed by the team during the design process, I now move to the analysis of the factors that were found to influence creativity in this project.

Factors Influencing Creativity in the F2F Design Team

My analysis elicited a number of factors that influenced team creativity in this F2F project, in relation to both the team and the organization. In the analysis that follows, I include sample verbatim quotes and photographic material I gathered in order to strengthen my arguments.

The Role of Alpha: Organizational Influences on Creativity

A number of organizational characteristics were found to influence the team's creativity, including the organizational approach and availability of tried and tested practices.

First was the openness with which Alpha allowed the participants to approach the task and the level of freedom with which the participants generated ideas that, during the early stages, were not strictly related to the customer's patent. In other words, though the design task itself was very specific and therefore limiting in terms of what the final solution should look like, Geoff encouraged the team to be open and think divergently of possible solutions during the early stages of the design process.

"Initially it was really good [Geoff] gave us the freedom to do anything pretty much having a blank canvas, the problem was quite vague, it was a very prescribed problem, it could be from a wide range of applications and a wide range of boats, so you couldn't necessarily picture what it was going to be like it could be lots of different options and different types of products out there which did the same thing..." (Patrick, F2F Interview)

This approach is commonplace at Alpha because it widens the designers' solution space; in other words, thinking divergently at first may bring to light solutions that the client may have not thought about:

"... regardless of whatever type of client you're working with, we go through that process so we very rarely sit down and think about one solution, there is an exploration of a lot of different ideas, just thinking beyond what they think the

solution might be and then coming back and the solution can be in an improved form." (Geoff, F2F Interview)

Further to the larger number of ideas, this openness promoted a better understanding of the design problem which later proved conducive to the team's creativity:

"... how we might solve the problem with no restraints it would help to think what the best solution might be, to help you understand the problem in general as well and give you some background research and what happens when people go overboard and what scenario that is then. Helping to understand the problem and thinking about it **without any restraints**. You don't think I have to make a ladder **you think about the whole problem and that helps with the general understanding of the task.**" (Patrick, F2F Interview)

Moreover, Alpha is an SME with experience in the field and availability of tried and tested practices. Despite the open character of the approach to generating ideas, it was found that this process was still controlled, and it largely reflected the organization's usual practices. For example, the openness discussed earlier was aimed at looking at the bigger picture first and then narrowing down the scope of the project by selecting the ideas that were considered suitable, thus reflecting a common practice within the organization. As Geoff put it,

"Rather than doing a complete brain dump, we started off by painting the big picture and saying **what does this product consist of** and pick off each sub element of it bit by bit and focus on that and generate ideas and **then review them all** at the end and **see the best sub-solutions** and therefore pull them together." (Geoff, F2F Interview)

It follows that the design process that was followed by the team comprised an organized and structured collection of actions that, though open at the start, aimed at, and resulted in, a handful of useful ideas that ultimately solved the design problem.

Another organizational practice that aided the team's creativity was that of sketching their ideas on flipchart papers and hanging them on the wall. At first sight, this may seem to be incorporated in design training; therefore it would be expected that all designers regardless of context (educational, industrial, etc.) employ this practice. At Alpha, having a pictorial image of all ideas of one projects hung on a common wall surface constitutes standard practice:

"... I'm a big fan of capturing everything on paper putting it on the wall so you can stand back and see all your ideas at once and cross fertilise ideas if you don't do a like that you can't do verbally as far as I'm concerned you can't really work in books because books are very linear, you work in a linear fashion and you can't stand back and look at all your ideas in one go it's much more difficult to see the big picture in books, we worked on layout pads and you turn the pages out and put them on the wall, it means you can refer back to any stage in that week to an idea of the previous stage in seconds and you know where it is, and it becomes a map of your thinking and it's a graphical way of working it really adds to the creative process." (Geoff, F2F Interview)

All participants recognized, both during the project and also in the interviews, the importance of shared wall space as part of their work as designers. Therefore, though this can be seen as an individual preference, in this case, using the wall space for idea sharing constituted an organizational practice. Clearly, this practice constituted a tool for progress monitoring and work organization; and it added an advantage that other similar methods cannot offer:

"... three months later I know where the various sections were on the wall, I think over here we have a lifting mechanism and down there we have the platform [...] trying to have a map a road atlas and trying to do that with words you can't do it." (Geoff, F2F Interview)

Another purpose of having wall space is idea sharing. Commonly, during my observations, one participant would hang their draft sketch on the wall and would talk the other two through it. However, the participants only hung their sketches on the wall when they wanted to show one another something at the team level; if only

two of them were present, they would typically do so by simply using the table as a platform for communication. It follows, therefore, that what is unique about the wall space is the fact that it can be shared and that the team can refer at any stage of the project, making sharing ideas at the team level an effective and effortless activity. In the two pictures in Figure 39 I show the progress the team made in this regard during the first five days (Day 1 – Day 5). The picture on the left was taken on Day 1 once the team started hanging their sketches on the wall, and the second on Day 5 when most of the core ideas that were taken further had been produced and put up.

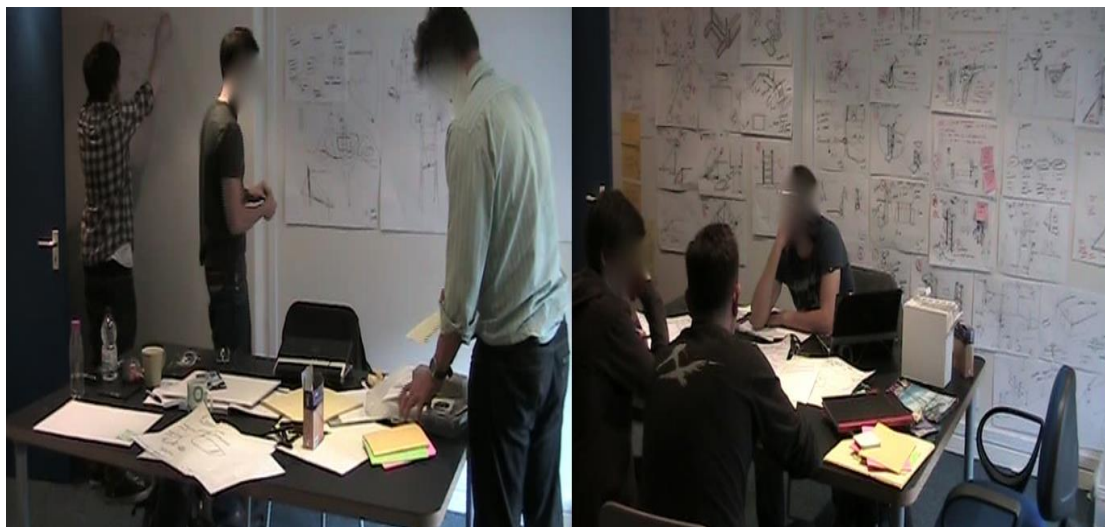


Figure 39: Progress Exploiting Wall Space

Notably, the two junior participants found themselves in a professional setting where established practices, tools and techniques were in place. Though this was no news for Geoff, it was found to be a different work environment for Patrick and Steve to what they were used to work in. Oftentimes at university workshops and other assignments during their university life, the two had limited or no budget or had no materials that would enable them to prototype their designs. In addition, Patrick and Steve's design-related experiences in university settings (e.g. in the form of assignments) involved plentiful paperwork which they, as students, had to complete in order to be marked. In an organizational environment, however, Alpha's culture did not require the team participants to be involved with paperwork or other tasks that were not strictly related with their main design task. Design training at the University where the junior participants had been educated, specifically, is arguably heavily paperwork-oriented. Therefore, the junior participants found that, in this

project, there was much more time for creativity than in their previous, academic design experiences. As Geoff argued,

*“... [some] students are encouraged to be much more about pragmatic and practical about creativity and less about writing reports, and [Patrick and Steve’s University] I think is still too focused on documenting everything and justifying it in writing it to the detriment they don't get the chance to familiarize their design [...] [Patrick and Steve] have had to do much more design work and problem solving to get to that stage [in this project] than writing reports. I think for them it might have been a bit of surprise to see it's not a formal we are going to do lots of calculations and stuff that comes later, when **you realise your ideas in some physical form** then you go back and you focus your analytical effort much more focused analysis.”*
(Geoff, F2F Interview)

Therefore, the fact that the team participants were not preoccupied with such peripheral tasks as writing reports or justifying what they were doing added to the organizational freedom at Alpha and was found to be an enhancer of their creativity; they had considerably more time available to deal with the design task in comparison with previous experiences of theirs at University.

Lastly, another organizational aspect that helped the team’s creativity was the fact that the participants were not concerned about keeping their work space clean and tidy; their task, especially during the early stages of the project, was to generate and share their ideas. Having an unstructured work environment, or in Geoff’s words, *“the ability to knock things together quickly and make a mess and not have to worry about tidying things up every night.”* (Geoff, F2F Interview), gave the participants the freedom they needed in order to generate ideas. As Geoff argued:

Further to the organizational influences on creativity in this project, I identified a number of team-related factors influencing creativity.

Team Composition and Dynamics

This was a highly homogeneous design team in most aspects. During the two projects, I observed no major disagreements, conflict or competitive behaviours between the participants. Though they had not worked together as a team of three prior to the first project, nor did they know one another well:

*“To be honest I didn't know [Steve] that well, I obviously knew who he was but **we hadn't actually spoken person-to-person that much**, we've done together the same workshop, but **I didn't know him personally that well**”* (Patrick, F2F Interview),

they considered that the dynamics between the three were good and constitute reason why the two projects went well. They also opined that their similarities and the fact that they were creative individuals enabled them to be creative as a team and understand each other's viewpoints:

*“... with other creative people **you can just work instantly on the same kind of thing and bounce ideas off each other without knowing them**, even if you had known them for a long time, it would make a difference, you would know the way they think.”* (Patrick, F2F Interview)

In addition, there was a high level of respect to one another, which allowed for freedom to express new ideas. The participants realized this when, in their interviews with me, they compared the team dynamics of these two projects, with other past experiences of theirs:

*“People can be put off by **having their confidence shot down a bit by somebody who's more cocky** they are quite keen on their idea and not wanting to explore other people's ideas they can stifle creativity within the group because they won't put some stuff forward because **this is my idea**.”* (Patrick, F2F Interview)

Barring the issue of respect, though their homogeneity is largely what contributed to them working creatively together in the two projects, it is also what restrained their creativity as well. The participants in fact realized that had they had people from

diverse background in their team, this would have brought more, new and different ideas to the table:

*“Potentially **if there was another student or another person rather** [he corrects himself replacing ‘student’ with ‘person’] than two people, the differences in how many more concepts we may have come up with or may not have come up with [...] maybe one other person **from another background** [...] somebody **who's been working for a few years but not as many as [Geoff]**, so someone from **a slightly different stage in their career** might have helped...”* (Patrick, F2F Interview)

The quotes above highlight the high degrees of homogeneity posited particularly between the two junior participants, Steve and Patrick, and the absence of team members from different backgrounds may have had a negative effect on the team's creativity overall; potentially, a more heterogeneous team would have contributed more creativity in the two projects. Notwithstanding this, the team's size was considered good by all in terms of creativity:

*“... I think three worked out quite nicely because we had **enough time to think individually** but then also **share your ideas with without being drowned out by a few other people.**”* (Patrick, F2F Interview)

It follows that, overall, the manner in which the team was composed, same for both the F2F and the virtual project, was predominantly beneficial for its creativity, with the exception of the issue of homogeneity, which potentially meant fewer ideas.

Leadership Style

I identified two leaders in the three-member F2F team under study. Expectedly, the person responsible for the whole project was Geoff. His leadership during the F2F project was not clearly articulated or agreed upon, but it went without saying, given that he was the owner and manager of the organization, the one in contact with, and also representing, the actual customer, and the one to determine the way forward every day and to make definitive decisions. Geoff was therefore a clearly accepted leader throughout the F2F project.

However, given that Geoff was often absent, due to issues I will be discussing later, Patrick emerged as a leader too. Patrick took the initiative early on to suggest how the task elements would be split between the two junior participants. His approach was strength-based, namely each of the two junior participants would assume responsibility of elements of the design task that they felt comfortable with and/or good at. During my interview with him, he showed awareness of the fact that he too was a leader in a project, when I enquired about who would decide how the team would proceed in Geoff's absence:

*"In that sort of scenario, I tend to be more naturally leader-orientated [...] it became clear from the offset that Steve was a bit more competent on the CAD so **it was to our strengths** [...] it wasn't really a discussion as to who was going to do this, it was you were good at CAD see you might as well do the CAD. **He was happy to do that** and I said oh well I will work on the ratchet design because I enjoy that and we bought it together at the end into one."* (Patrick, F2F Interview)

It follows from the quote above that Patrick emerged as a leader based on the competences of the two participants (Steve and himself), and that he too was an accepted leader.

It was also recognized by both Patrick and Steve that Geoff's leadership style was such that not only did it allow, but it also encouraged the generation of ideas that were not strictly relevant to the initial patent requested by the customer. In other words, Geoff leadership style was twofold. On the one hand, his leadership was one

that gave way for all ideas to be heard; it was democratic and non-authoritarian and it was exercised as if there were no organizational hierarchies:

*"In the creativity brainstorming bit I think he was equalled he didn't think he was managing us **we all spoke freely and openly about our ideas** without any kind of prejudice between experience or positions **he treated us at the same level as he would any professional person, he wasn't like a boss** or anyone like that at that stage."* (Patrick, F2F Interview)

I also posited an element of respect regarding the manner in which leadership was exercised. From the very beginning of the F2F project, Geoff prompted Patrick and Steve to provide their opinions and ideas; and he heard them with enthusiasm. Patrick noted that this element of respect was present at all times, among all three:

*"... **we all listened to each other and what they said allowed us to be quite creative** and no one was really holding anything back or holding anyone else back..."* (Patrick, F2F Interview)

*"he had a different approach where **he was willing to take the time and over the initial stages, instead of just jumping on the first idea**. It's good to spend time on the initial stages because you can invest a load of time in an idea which you have just picked straight off, and then realise later on that there was a much better way of doing it."* (Steve, F2F Interview)

Therefore, through this democratic and participative leadership style, Geoff ensured that the team would have a large pool of ideas to draw on at the later stages of the design process.

On the other hand, however, however open to hearing new ideas Geoff was, he was the one to make decisions as per which ideas would be taken further and which ones would not. Therefore, his leadership was important in terms of idea selection, structure, and planning the steps ahead:

*"[Geoff] was steering the whole ship. And it's [Geoff]'s workplace so **he has the ultimate say**, you have an idea and say what about this and if he doesn't like it that's it [...] As a team it was quite good dynamics."* (Steve, F2F Interview)

The Effects of Physical Proximity

Central to team creativity in this project was the issue of physical proximity. Indeed, the participants in this study were mostly sitting in the same physical location, doing work collaboratively-individually together in this F2F project. In other words, constant presence was found to be helpful even when individual work was being performed:

*“We had sections **were working independently opposite each other, but then I would ask [Steve] what he thought about this idea, is this good, do you like it, any improvements, and he would tell me what he was working on, so we had check-ups on each other whether we thought like sanity checks.**”* (Patrick, F2F Interview)

Therefore, physical collocation meant that participants would discuss—and work on—their ideas even in an informal fashion while working independently. This had an enhancing role for creativity, as one’s thought would often complement the other’s idea:

*“... it's always good to have someone else there **to bounce ideas off** and you usually find when you do ask somebody about something **they will come back with something that you're not expecting you haven't thought of previously** said helps to expand maybe the initial idea.”* (Patrick, F2F Interview)

Further, while sitting in a collocated environment, one is also able to borrow, or instantly see, ideas from a teammate. Importantly, this often leads to different interpretations of existing ideas, which can in turn generate more useful or original ideas:

*“If you are next to people you're scribbling down ideas it does help because **you can get ideas from other people quite easily**, because a lot of ideas you get from somebody saying something they have an idea and you interpreting it wrong and you saying that is all right we like that but then I know I wasn't thinking that but yes that is better”* (Steve, F2F Interview)

In addition to the ease with which one can generate ideas in a F2F environment, communication speed constitutes another factor that enhances creativity at the team level:

*"... **sitting next to somebody** and scribbling ideas down I think does definitely help you generate ideas as well. **It's quick and you can get things from each other instantly.**"* (Geoff, F2F Interview)

Moreover, it was found that working in a physically collocated environment had an emotional impact on the participants, as they considered teamwork to be a more enjoyable process. As a result of this, close physical proximity aided the team's creativity indirectly, as the participants were feeling happier, more focused, and more task-oriented when surrounded by teammates:

*"If you are there working **together it's more enjoyable** and **the whole process is more exciting** and **you're more engaged and alert** and **thinking about it more actively** where if you're on your own you can just lose motivation or just get distracted your mind wander without noticing it makes you **more alert and focused on the task at hand** helping you to come up with stuff be a bit more creative"* (Patrick, F2F Interview)

Being physically proximate meant that the participants were able to prototype their ideas, evaluate them in practice, identify further problems, and explore them from the end user's viewpoint. Developing an actual prototype gave way to the generation of more ideas:

*"... we did spend quite a large amount of time like a couple of days in total making the thing but it is worthwhile well partly because you get to learn how everything fits together and you know and if it's the right and having it there you can actually well **that's a really piddly bit you can have it a lot thicker** but also it's good for the customer as well **if you go around showing a CAD model of something you don't really get the same idea.**"* (Steve, F2F Interview)

Problems emerged while prototyping, giving rise to more ideas:

*"Still in the final couple of days we were still deciding on the ratcheting system, and we wanted some sort of release system, because you want to quickly drop the ladder if somebody has fallen anyone to drop the ladder quickly, but you want **a system that you can't accidentally knock** and **then while you are climbing up you can't smash back in.**"* (Steve, F2F Interview)

Absence

Absence was one of the factors that influenced the team's creativity. It soon became evident to both junior participants that in an organizational environment several projects are being run simultaneously by the same individuals, and therefore, not all individuals of an organization are expected to be constantly and exclusively engaged in one task; though, obviously, the current two projects constitute an exception as the junior participants were temporarily recruited for the purpose of this research and had therefore no other commitments. As Geoff himself commented,

"Now I had to do some work for the Royal Academy, I was a judge, I don't ever have clear weeks." (Geoff, F2F Interview)

During my observations I often asked Patrick and Steve where Geoff was, and they would reply that he had other commitments. Geoff was predominantly absent during the second week (Days 6-10). Insofar as the impact of his unexpected—to the junior participants—absence is concerned, this often meant a change in direction:

*"Being away and not being here is a big one, because if I'd been here, cause **the guys had pursued some routes and I came back and I changed their direction** slightly after they after they had done work in a particular way" (Geoff, F2F Interview)*

However, the junior participants—as soon as they realized that they would not work as a team of three at all times of the project—organized and distributed their time and work accordingly:

*"The second week me and [Steve] were left to it because [Geoff] was busy with his other commitments that **we worked more on the detail so we were doing some research on the materials** we wanted to use whether it was suitable and strong enough." (Patrick, F2F Interview)*

8.5.2 The Virtual Project: A Double Glazed Sash Window

Here, I present the findings from my analysis of the virtual component of the study. I begin by describing the VDF lifecycle and design process with a focus on creativity, and continue by presenting the participants' perceptions of creativity. Subsequently, I discuss the management issues that were found to influence creativity in this project, as well as the relationship between creativity and the unique characteristics of virtuality.

The Virtual Design Process and VDT Lifecycle

The participants worked from three different locations as it had been previously agreed. Patrick worked partially from a shared office of researchers and partially from home, Steve worked from home, and Geoff worked from his office but also while on the travelling overseas. Geoff was mainly on the go during this project, due to other professional commitments, and therefore, he was less engaged in it than he was in the F2F project. Therefore, most of the work was done by Steve and Patrick. During my interview with Geoff, he would often respond using *they* when I asked how did the VDT go about something, suggesting that he was not always an active participant. Therefore, much of this project was performed by a dyad of participant and not by a team of three. As discussed earlier, unexpected absences where a team member may become unavailable within a project are not infrequent in industry.

Overall, the two participants communicated via Skype to set targets, discuss their progress, exchange ideas, and establish steps forward. They also used Skype IM for minor coordination issues, such as agreeing what time they would meet next.

The Skype IM and Group Calls data show that the team's communications were both task-related and of social nature too, similarly to the F2F project. For example, it was observed from early on through to the last day that the three participants updated each other on personal issues, such as what they would do next. The frequency of use of ICTs with high degrees of synchronicity (i.e. IM and voice-over-IP) was high, while completely asynchronous communication (i.e. email) was minimal. The main collaboration ICT they used throughout the project was Prezi—a software program mainly used for presentations. Prezi allowed them to monitor their progress

regularly and was shared among all three. Typically they all met virtually as a team of three at the end of each day, whereby they went through the work done and sought for Geoff's opinion and further direction. Steve and Patrick, however, usually used synchronous ICTs to communicate up to three times a day. Most meetings were voice-only (i.e. Skype Group Calls) and no video was used. During each virtual meeting, the participants watched an updated version of their Prezi file.

Early stages: launch and organization

At the kick-off on Day 11, Geoff sent Patrick and Steve an email outlining relevant information about the product the team would have to work on, and followed it up with a Skype Group Call. Technical difficulties prevented them from having Steve on the same Skype Group Call. The two participants started to share negative experiences of them working virtually in past projects, whereby one highlighted the number of technical difficulties faced (Geoff) and the other concurred and elaborated emphasizing communication-related issues he encountered during his placement when partaking in a project between the UK and Spain (Patrick). Clearly, therefore, the two participants viewed virtuality as a constraint that had been imposed to them. Once communication was attained among the three, Geoff—assuming a leadership position as in the F2F project—addressed three issues: (a) a simple combination of communication tools they would use to collaborate; (b) each participant's availability and preference in terms of the location they would work from; and (c) the aims of the project. The aim of the project would be to generate some ideas about a potential solution, without however jumping straight to it. He suggested,

*“if we can spend **this week exploring and investigating** and then **next week detailing**, this will give us some time to come to some sort of useful conclusion.”*

(Geoff, Day 11 meeting circa 10:30, VDT observation extract)

Further to setting the aims of the project, discussing availability, and exploring patterns of communication for the duration of the project, during the first meeting, Geoff gave five directions that guided Patrick and Steve's forthcoming work: (a) possible solutions currently available on the market; (b) cost issues; (c) time issues;

(d) different materials (e.g. polycarbonate and also more flexible materials); and (d) system—looking at a business solution level.

The remainder of Day 11 was focused on market research, which gave rise to some ideas. Specifically, the junior participants researched what is available on the market to improve insulation of traditional sash windows—often found in old buildings in the Southwest of England and elsewhere. The junior participants performed individual brainstorming in addition to Internet research and gave each other quick updates via Skype IM. The two agreed on four criteria their solution should satisfy: (a) the solution should be a system, not an individual product; (b) it should be easily measurable; (c) it should be easily fitted into the sash window; and (d) it should be easily removed and stored. These criteria were used to guide their market research and brainstorming at that early stage of the design process. Once individual research was accomplished, the participants discussed their findings and identified pros and cons for each idea. At the end of Day 11, the team conducted a Skype meeting and built on each other's ideas using Prezi to guide one another through their individual progress. During the meeting, they discussed ideas about how they could measure, cut, fit, and remove and store the prospective end solution, generating thereby a large number of ideas. The meeting closed by outlining expectations for the next day and agreeing on another team meeting at the end of the following day.

Ideas' generation, sharing, and Computer-Aided Design

On Day 12 the participants built on the key ideas generated on the first day and produced the highest number of ideas ($n=64$). Their work from that point was based on the directions agreed on the first day. Geoff emphasized to the junior participants the importance of using the pen and paper technique, though they were all geographically dispersed and therefore the value of this technique would not be the same as it was in the F2F project, where they all had the opportunity to look into each other's outputs instantly and effortlessly. The junior participants took a deeper look into the materials used in the products they identified during their Internet search and borrowed some ideas that could be potentially applied to their concepts. Day 12 also involved decision making, during the VDT meeting; it was then when

the design problem presented to the junior participants and develop a selection of them further. Therefore, no final products were ultimately prototyped. My analysis identified 215 design ideas over the VDT lifecycle, which I present in an unorganized form in Figure 40 above. Figure 40 presents the words that related to the identified ideas as were found in the raw data, before the analysis. Though the key ideas around which the VDT worked emerged during the first week, the participants continued to be creative during the second week through virtual discussions on technical and functional issues. For example, certain materials that were suggested for certain parts of the design (e.g. about the frame) were very expensive to use. Other ideas concerned details about providing a service, including not only the window *per se*, but also the process that was necessary in order to replace an existing window. Overall, creativity occurred most days during the VDT lifecycle, and it peaked on Days 12 and 15, as also shown diagrammatically in Figure 41, which is based on my visual analysis of the generated ideas.

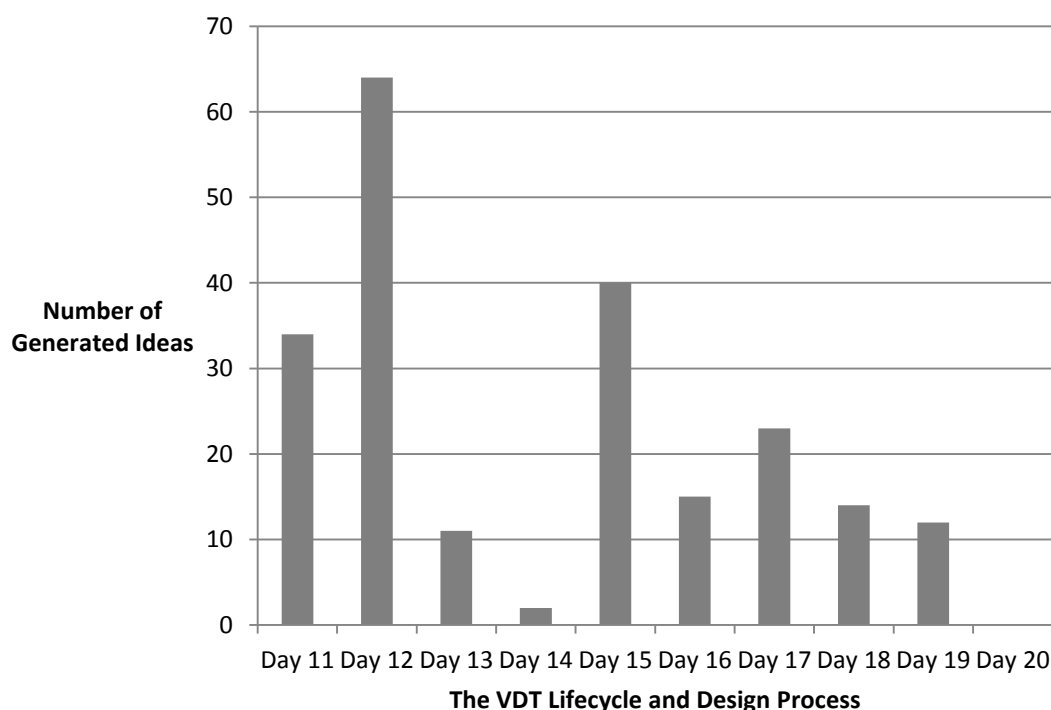


Figure 41: Creativity in the VDT Lifecycle (after Excel in Appendix G)

In the next section, I discuss the participants’ perceptions of creativity in the VDT.

VDT Creativity: Perceptions and Generated Ideas

Overall, Geoff was happy with the creativity in this project as well:

“... I was quite pleased; we did actually come up with lots of different and diverse solutions.” (Geoff, VDT Interview)

Yet, during my interviews with the participants, they all shared with me their concerns about working virtually:

*“... all the time when you're designing something and you're sitting down designing what you are doing is you are starting from here, and to get to there, there is a series of small improvements and changes, **it's like climbing a set of stairs from one place to another and you have lots of steps and each of these steps represents a change or an improvement** or something, and **with this project it literally felt like there was much less refinement**. It's a crude process, somebody works on something in isolation, we have a meeting, they make some changes, they work on it in isolation, again we have a discussion, they make some changes, and you can do that maybe if there is one conversation a day **the maximum you can have in two weeks is 10 steps**, you would probably have less conversations [...] if there's a three-day project looking at the framing system we literally went through three steps.”* (Geoff, VDT Interview)

As it follows from the above quote, the virtual design process was perceived as a much slower one compared to the F2F design process. Geoff, in particular, also based on his past virtual experiences, was adamant that virtuality slows down the creative process. As he argued,

*“**[Working as part of a VDT] is much slower [...] it really comes down to speed**, we have a natural pace we work out in the conceptual stage it's very intense, so lots of ideas, and it feels very frustrating **just the pace is very slow probably five times slower and that feels very frustrating**.”* (Geoff, VDT Interview)

An additional finding that emerges from his views is the emotion of frustration due to the reduced pace of interaction and idea sharing, and its adverse effect on

creativity. However, though all participants acknowledged some of the difficulties brought about by the issue of virtuality, the VDT was able to be creative at the team level, as both the participants and also my analysis have suggested.

Despite the ideas that were generated at the team level, there were misunderstandings that slowed down the team's progress. These misunderstandings were not brought to light early on, but when the designs started to take shape:

"... a blind idea with two rollers, and then there was another completely separate solid glazing thing, so the blind idea was a roller like a flexible film. And because [Patrick] mentioned a blind thing that triggered ideas, I then went away and drew a concept of a blind, I think he just described it, I don't think he had a sketch for it, I think he had an idea that we were talking, because I didn't see an image [...] so I thought I would draw up as well, so what he described was different from what I had, then we put the frame in as well to secure it, and basically recombined a lot of ideas. So it had the roller idea but just at the top but it didn't have [Patrick]'s roller which we realized was a bit over the top and it wasn't necessary. I think [Patrick] was talking about magnetic strips, so we had that on there as well, so we chatted the first day or two and just combined loads of the ideas, and I quite liked that idea, it was a good idea." (Steve, VDT Interview)

Steve's quote highlights the importance of photographic material for communicating ideas within a design team and reinforces Geoff's arguments from the F2F component of this study that sharing design outputs on a common surface that is visible to all is crucial in design. In this virtual component of the study, despite software availability—which I will be discussing in more depth in the following sections—the participants experienced reduced visibility of each other's ideas.

Geoff furthered this view by arguing that—in a virtual environment—ideas cannot always be prototyped; or that the value of prototyping them in a virtual environment is not the same for all participants:

*"The other thing I guess a problem with working remotely is **the [in]ability to prototype, to review the prototype, and make decisions based on that. You just***

can't do it. In the [F2F] project, we build in plastic tube a model of the ladder and we all sat around and looked at it and the changes we made as a result of having built and tested the prototype, and spent time in the workshop. With this you can't do it, one person can build a prototype but it's much more difficult to share how it works with the others. One of us could build it and test but the other two wouldn't be able to have the experience of being users." (Geoff, VDT Interview)

Hence, though the participants did appreciate the value of working as a VDT (for example, Geoff has previously worked as part of a global VDT), the participants gave their views based on this and other projects of theirs, which show that working as a VDT is not ideal for creativity. In the following section, I present the management issues that were found to influence creativity in this project in my visual analysis and analysis of the team's communications.

Management Issues Influencing Creativity

In this section, I explore the management issues that were found to influence creativity in this project through the visual analysis and analysis of the VDT's communication outputs, and I explain how these relate to the team's virtuality. A synopsis of these issues is provided in Table 22 below.

Table 22: Management Issues Influencing Creativity in Study 3 VDT

Management Issue	Explanation
Communication and collaboration	The team encountered significant challenges in trying to both communicate and collaborate with one another.
ICT selection and use	The team devoted disproportionately large part of their time in selecting, understanding, and educating on another, on issues of ICT selection and use. Further, ICTs often crashed and offered unsatisfactory results.
Boundaries, visibility and availability	CMC created boundaries that importantly decreased visibility within the team and exacerbated issues of unavailability.

Much of the VDT's time was devoted to ICT selection from early on (Day 11) in the VDT lifecycle. For example, though the team started using Skype for their communications both in writing (between the two junior participants) and also in speaking (using Skype Group Calls), they were not happy with the fact they could not see one another. Given this limitation, they tried other available programs, but with no success, as they could not always make them work. What is more, I found that these attempts took a large part of their time:

"[6:16:25 PM] Steve: Hows google+ going?"

[6:16:36 PM] Steve: Its pretty buggered at my end

[6:17:01 PM] Patrick: make it work

[6:17:04 PM] Patrick: lol

[6:17:36 PM] Steve: I didnt think of that... I'll give it a go, cheers" (VDT, Skype IM, Day 15)

Further to communication issues, the team also faced problems sending, sharing, and working collaboratively on their ideas:

"11:50:46 AM] Patrick: do you want to forward some of the stuff you have found?"

[11:51:03 AM] Patrick: I can pull together into a single document?"

[11:51:32 AM] Patrick: actually prob best to do this later

[11:52:55 AM] Steve: yeh, I've got it written down alright (like we did for the last project)... maybe put it all together at around 4:30?" (VDT Skype IM, Day 11)

I identified numerous technical difficulties the team faced while trying to work collaboratively together. For instance, Geoff often found it difficult to share his thoughts visually with the junior participants—though Prezi, the main collaboration software used by the team—was visible to everyone, its use was found to be problematic. At first, the participants were not fully aware of how to use it, while, as time passed, the file became bigger and started to crash, interrupting the team's creative process. In fact, all ICTs used were found to fail at various different times during the project:

"[7/19/2011 5:17:04 PM] Patrick: my presi is going abit mental" (VDT Skype IM, Day 12)

"[1:22:25 PM] Steve: My skype buggered up" (VDT Skype IM, Day 12)

"[2:55:32 PM] Patrick: sorry skype and computer decided to kill itself

[2:56:37 PM] Steve: well i didnt even notice

[2:56:47 PM] Steve: how long were u gone?"

[2:56:57 PM] Patrick: 30 mins ish" (VDT Skype IM, Day 22)

"[4:29:02 PM] Patrick: skype has been continually crashing my computer

[4:29:09 PM] Patrick: think its sorted now" (VDT Skype IM, Day 22)

Another important findings relates to the effects of CMC on the team's collaboration and creativity. It was found, more specifically, that CMC gave rise to boundaries of visibility, clarity and uncertainty, as the excerpts below show:

"[10:21:13 AM] Steve: yeh same... but u just appeared on my skype when I wrote that message

[10:21:25 AM] Steve: did I just appear on ur skype?

[10:21:36 AM] Patrick, you were offline until you spoke to me

[10:21:56 AM] Steve: i seeeeee....

[10:22:12 AM] Steve: well anyway yeh I've read the email" (VDT Skype IM, Day 21)

Numerous times during the project, the participants found it challenging to manage this uncertainty that was found to be intensified by the CMC:

"[2:12:39 PM] Steve: you back?" (VDT Skype IM, Day 18)

"[4:28:32 PM] Patrick: Still no word.

[4:28:42 PM] Patrick: I imagine he will ring at 1700 or something

[4:28:57 PM] Steve: Fair enough boyo" (VDT Skype IM, Day 18)

"12:26:07 PM] Patrick: you heard anything

[12:27:45 PM] Steve: nope

[12:28:02 PM] Steve: I thort he would have phoned you?" (VDT Skype IM, Day 20)

And also the lack of clarity that was found to influence their collaboration effectiveness and creativity:

"[4:18:41 PM] Patrick: where is the drop box file

[4:18:42 PM] Patrick: ?

[4:19:25 PM] Steve: Have you checked ur emails?

[4:20:20 PM] Steve: [Geoff] should have emailed you, about an hour ago, with an invite to the new file" (VDT Skype IM, Day 11)

"[5:43:37 PM] Patrick: how do you get exploded views in to draft drawings

[5:43:40 PM] Patrick: ?

[5:44:16 PM] Steve: can't remember, I'll have a look in a second" (VDT Skype IM, Day 22)

Further to these issues of reduced visibility within the VDT, I identified issues of unavailability influencing the team's creativity, as the junior participants oftentimes felt that Geoff was unavailable:

"[Geoff],

Just wondering when you next want a project catch up?

All content is being uploaded onto prezi - feel free to make comments

directly into the prezi.

Cheers,

[Patrick]"

(VDT email, Day 12)

"Hey [Geoff],

Me and [Patrick] have been trying to contact you, to go through the work we've been doing...

Could you contact us when you get this email?

Cheers

[Steve]"

(VDT email, Day 19)

Following these issues that were found to influence creativity in the VDT, I proceed to explain how the unique characteristics of virtuality, in particular, were found to influence creativity in this study.

Creativity and the Unique Characteristics of Virtuality

A number of issues emerged, suggesting that—though creativity in this project was rated high by Geoff—creativity at the team level was not the same as in the F2F project; though the participants in the VDT were able to generate plentiful ideas on their own, thus at the individual level, the unique characteristics of virtuality mostly prevented the participants from attaining high levels of creativity as a team. In what follows, I discuss how geographical separation and the use of technology (technology and CMC)—the unique characteristics of virtuality that emerged in my analysis—were found to influence creativity in the context of this project, based on the interview data.

Geographical Dispersion: An Enhancer and an Inhibitor

As it had been *a priori* agreed, the participants would be geographically isolated from one another, and, therefore, no locational subgroups would be formed within the VDT. Geographical dispersion influenced creativity both positively and negatively. Contrary to the F2F project, in which brainstorming was performed collaboratively, in this project it was performed mostly individually:

“... we did some individual brainstorming when me and Steve would also talk occasionally through Skype or through messaging on Skype or just to give each other a quick update on what we are doing to make sure and talk about the ideas we had come up with.” (Patrick, VDT Interview)

The participants argued that, despite the challenges, performing brainstorming individually was largely good for their creativity, because it offered flexibility and space to understand the project better, in particular in the early stages:

“Working independently on your own is quite useful to think clearly [...] I came up with the roller blind concept just by working and thinking about it on my own [...] Initially I think the initial creativity and having some of your own time and space can help me to just think clearly about the problem [...] I think right at the beginning of the project I find that time in independence quite useful just to think through some concepts.” (Patrick, VDT Interview)

As the above quote shows, the participants interpreted working individually as working independently from one another. In this regard, geographical dispersion was found to increase the participants' sense of ownership and responsibility over their own ideas, taking initiative over the next steps. Further, working independently meant to them less distractions and higher productivity in terms of generated ideas:

*"... **you can get on with your own thing you decide what you're going to do and then get on with it and then meet up again, so [working virtually] is a bit less distracted** [...] get on with your bit and then come back so it could be more productive in that way."* (Steve, VDT Interview)

On the other hand, geographical dispersion inhibited the participants from following organizational practices, such as the use of *pen and paper*, which, by extension, influenced the visibility over each other's outputs as well as the speed of the creative process at large:

*"... because there is a tendency when all working [F2F], I'll force them to work with pen and paper so you see the output [...] **they were much more inclined to either use the computer with CAD which just slows things down.**"* (Geoff, VDT Interview)

What is more, geographical dispersion inflicted feelings of isolation, influencing the participant's ability to be creative:

*"I think **it was basically giving you a bit of a mental break if you sat there on your own the whole time**, I find it's good for a certain period of time but **you can hit a wall where your creativity seems to be stifled** and talking to other people about it seems to help [...] we have often found **when you work on your own through the day** [...] **you get a bit fed up where you're not coming up with anything particularly new** [...] I find that time in independence quite useful just to think through some concepts, but **there is a certain kind of time-limit on how long you can do that.**"* (Patrick, VDT Interview)

This last quote points toward the time aspect of working individually; Patrick found that the sense of independence and autonomy can soon turn into a feeling of isolation, which can inhibit his creativity.

Geographical dispersion was also found to raise boundaries between the participants, which reduced the level of personal contact, as well as the level of visibility over each other's work:

*"... it is very frustrating **you feel like you have one hand tied behind your back partly because of not being F2F** I think being F2F and working with people and being able to interact and being able to interact on a personal level."* (Geoff, VDT Interview)

Moreover, geographical dispersion led to the realization that the presence of physically proximate colleagues—which was not the case here—can act as an enhancer of creativity. Thus, geographical dispersion made it harder for the team to bounce ideas off each other:

*"... if you've got people there to stimulate you and talk about things, then you can be more productive and get more done in a certain time scale. Other than having a bit of time and space on your own to think clearly, I don't think there were any other benefits [of geographical separation] really in terms of creativity [...] **just having people to talk to you stimulates** the more it keeps me going I can do a few hours my own I get a bit fed up and stop being that creative I need a decent break [...] if you **sat in the same room with a pen and paper we can see and talk about what you're doing in real-time** you can get more done in the same time period [...] whereas if you have other **people to talk to and bounce ideas off** a kinda keeps me going for longer and I get more done in the time."* (Patrick, VDT Interview)

Importantly, geographical dispersion inhibited the participants from prototyping their ideas:

"the ability to a prototype, to review the prototype, and make decisions based on that, you just can't do it in the first project we build in plastic tube a model of the ladder and we all sat around and looked at it and the changes we made as a result of

*having built and tested prototype and spent time in the workshop. With this **you can't do it, one person can build a prototype, but it's much more difficult to share how it works with the others.** One of us could build it and test but the other two wouldn't be able to have the experience of being users.”* (Geoff, VDT Interview)

Geographical dispersion was found to be a significant inhibitor to creativity in that it did not allow for the subconscious visibility that often characterizes F2F work or the opportunity to build on each other's ideas before these take a final form:

*“... when you are actually together [in a F2F environment], you don't need to take set time aside and have a meeting to find out what you're doing, because **just by process of osmosis you are always conscious of what you're doing.**”* (Geoff, VDT Interview)

*“Not only does being able to sketch an idea and say here it is also quite good when you're doing it that way, maybe **somebody is halfway through drawing a design and then you're looking at it and that gives you an idea as you think he's drawn something completely different,** then maybe once he has finished the drawing, you realize and that is giving you an idea, but when there's a scanned in drawing ...”* (Steve, VDT Interview)

What Geoff and Steve's quotes above echo is their concern that much of the creative process is lost in a VDT. As they argue, in a F2F environment, one has visibility over the other participants' drawings as they are being drawn. This often triggers new ideas before an idea has taken its complete shape. Geographical dispersion was therefore found to inhibit the level of input put by different VDT members while an idea is being developed, significantly influencing creativity:

*“I guess **creativity comes of these bits the conversations the feedback** so I guess the guys are probably do a bit of this [...] there is a big change here with the guys working alone, they tended to have a solution in their head and they would model it up and they would make changes as a result having talked as opposed to if they were sitting down here drawing **I would ask what they were doing and we would all have a look and we would all say why do we do that and change this and you end up***

with much more incremental smaller changes but more of them and you will fine tune the direction you are going in.” (Geoff, VDT Interview)

It follows from this analysis that geographical dispersion both enhanced and inhibited the participants’ creativity for the reasons discussed above. Next I examine the role of technology in this project, focusing on both the use of technology and also the role of CMC for creativity in this VDT.

Individual Use of Technology

Unavoidably—given that the VDT participants were geographically dispersed throughout the VDT lifecycle—most of their communication and collaboration was computer-mediated. Their use of ICTs in this project was to a high degree for individual work and communication purposes and less for collaboration purposes.

The use of CAD in particular was found to be an enhancer of their creativity. Its use by the participants (Steve in the most part) was similar to the F2F project and enhanced their creativity by enabling them to look at angles of the concepts they were not able to look at before, giving rise to more ideas:

*“... when you are coming up with concepts [...] **I did some CAD very early on, because getting it is one thing, but I’m alright at CAD, so I’m quick doing the designs on CAD, so some of the concepts, you come to a point once you have sketched it and don’t know how to develop it further. If you CAD it up then you can see other bits of it.**”*

(Steve, VDT Interview)

It follows that the use of technologies like CAD was important for creativity and their uses were similar in both projects. Further to CAD, Internet was an important enhancer of their creativity as well. Similarly to the F2F project, its use as a search engine helped the participants to think of what is available on the market already and how it can be used for the present project:

*“It was another concept which we hadn’t thought of, certainly is another thing to look into, and it was quite an interesting concept, I took that initial idea from [Geoff] and **did a bit of research into how it works the materials involved and how applicable it would be for our project**, so I did some research on the Eden Project the Beijing aquatic centres all of the buildings that have used that kind of material and construction, **I found particularly interesting concepts** in the fact that you could alter the amount of air in the cell that you can control the thermal insulation properties, so if you had a small amount of air you would have low installation or if you filled up with air you had high installation and **scope to actually adjust the installation in the window.**”* (Patrick, VDT Interview)

Therefore, certain uses of technology at the individual level were found to be relevant in both the F2F and the VDT environment and enhanced the team's creativity. Next I discuss how CMC influenced creativity in the VDT.

Computer-mediated Communication (CMC): Exacerbating Problems?

The following themes highlight the relationship between creativity and CMC in this VDT:

Cost and Proficiency influencing ICT Selection

A task that was in a way imposed to the VDT—on top of their main design task—was that of selecting germane technologies for each subtask during the VDT lifecycle, and organizing, therefore, their work around the technologies that would be used. Obviously, though they still made use of technologies in the F2F project, in this project the importance of technology use was augmented, as it represented the one and only platform the team depended upon to communicate and collaborate, considering that this project involved no F2F communication whatsoever. For instance, the team used Prezi as an equivalent of the shared wall surface. Geoff was clear that only free technologies would be used for collaboration; he was also conscious about expensive ICTs that large virtual organizations use for collaboration, which, further to the high cost, require a high level of proficiency:

*“... I have used VC before, well **it is a very expensive suite** [...] it was just a whole bank of screens but it had overhead cameras and you could look at books and see real-time [...] it was just like looking through a series of Windows, it was like being in a prison and you're looking at them through a piece of glass, they were on one side and we were on another [...] we had one big table that just went through wall and they were sitting on the other side. **That was good but very expensive and not everyone can use that.**” (Geoff, VDT Interview)*

This suggests that a compromise in terms of the ICTs that would be used had been made in advance in Geoff's mind. He knew that this high degree of synchronicity and simulation of a real work environment—as with previous experiences of his described in this quotes earlier—would not be the case in this project, and he let the junior participants explore options that would be as germane and costless as possible, which led to technology failure and collaboration problems which in turn influenced creativity.

Artificial Character of Synchronous Communication: Quality, Accessibility and Delays

The team were not always able to work successfully in a synchronous fashion because Skype presented them with problems:

"I think Skype when you have three people I think it's okay with one-on-one chats but group chats it starts echoing, as it comes out of the speakers and back into the mic, so that was a problem and that was why on Friday the first week we just had the image, you should have one person's voice [...] we had to keep on stopping Skype and restarting it because there was an echoing thing built-up and it just sounded like it was underwater." (Steve, VDT Interview)

Further to issues of maintaining synchronous connectivity on Skype, their use of Prezi was also troublesome; though this software program is designed for presentation purposes, the team used it to share their ideas. Thus, as the following quote shows, Prezi raised accessibility issues:

"[We used] Prezi which is more of a presentation tool, than a sharing tool, to do the sharing of ideas, which is fine when it works, it was a little temperamental and it doesn't like big files, so it's grinding to a halt by the end of the first week, so we had to start with a new one so you lose easy access to what you have done before." (Geoff, VDT Interview)

But even when it worked satisfactorily, Prezi was still remarkably slow and oftentimes slowed down the collaborative creative process, insofar that the participants would lose their train of thought:

"It was slow, it was fine if you have everything dragging and dropping, but we tried sketching, but that was very slow [Geoff] would try it and he would say this thing here and then this thing here and you wouldn't see it until 20 seconds later, then you could have moved on to something else. You think you're saying this thing here, but actually you were talking about something completely different." (Steve, VDT Interview)

It follows that despite the highly, ostensibly, synchronous character of their use of Prezi over Skype, issues of quality of communication, accessibility to ideas the team had previously generated, and technical delays exacerbated the artificial environment created by CMC. The participants felt the need to compare this artificiality of the virtual environment to their experience of designing F2F:

*“... **you couldn't sketch in real-time and communicate in real-time very effectively.** It was difficult to have a tool that allows you to see what everybody was sketching. If you are sat next everybody with a piece of paper that is very easily done and you can progress quite quickly with ideas and concepts and also develop them a lot more quickly.”* (Patrick, VDT Interview)

Reduced Visibility and Slowness of Synchronous and Asynchronous CMC: Uncertainty, Time Limitations, No 'Chemical Reaction,' Reduced Productivity

The boundaries introduced by geographical dispersion in the project reduced the participants' visibility over each other's work significantly; what is worth noting is that the ICTs used did not help the participants to overcome this limitation. For example, this lack of visibility created issues of uncertainty:

"... when they were working remotely I'm not sure how much time they're putting in and how much they are there. If you're not due to call until five o'clock they might be off sort of shopping." (Geoff, VDT Interview)

Further to issues of visibility, it was found that the participants' creativity was significantly influenced by the issue of speed:

"... [in a F2F environment] the rate of sharing an idea and bouncing back an idea can be done in minutes, if someone is in a different place and it is done by e-mail it can take a couple of days [...] if they are collocated, you can have thousands of these interactions in the space of a couple of weeks..." (Geoff, F2F Interview)

Though Geoff, in the quote above which was taken from my F2F interview with him, before the virtual project was realized, takes the case of email—an asynchronous medium—his prediction was not far from what actually happened in the virtual project, despite the use of highly synchronous ICTs.

On the one hand, adoption of asynchronous practices for idea sharing was indeed inhibiting for the team's creativity:

"... what we did is we sketched our own thing and then scanned it in and then showed it" (Patrick, VDT Interview)

On the other hand, the participants felt strongly that using synchronous ICTs did not improve their creativity—rather, synchronous ICTs were found to be equally slow, giving rise to another set of inhibitors to their creativity:

"One of the major things that slowed us down was the fact that you couldn't sketch in real-time and communicate in real-time very effectively." (Patrick, VDT Interview)

*"It was quite challenging **working remotely is so much slower** as we predicted a number of issues for **that you can't easily bounce ideas off each other you generate ideas generally** by peoples sparking and they'll say something and it will trigger something and it's almost a cascade, if you like, **there is a chemical reaction** and because **our time is limited** we had one conference review ideally every day if we could and that is only an hour and so only an hour of shared time [...] it wasn't bad but just in terms of download rate and **the speed of reaction I could just about draw on the screen but the other guys couldn't see it the minute** and then the resolution was awful and **lots of delays** [...] You could do zoom in and get the presenter to zoom in and you can get into the detail, that was there, **it was quite a slow process**. You know when you're working with someone in the course of a minute you're probably looking at 20 or 30 different things in different scales to drive into the same and cover the same ground using that tool might take 5 min so **it's a much slower process**." (Geoff, VDT Interview)*

Geoff, in particular, considered that the slowness characterizing the team's CMC in this project gave rise to a number of issues inhibiting the team's creativity: time limitations, lack of *chemical reaction* triggering ideas, reduced productivity in terms of generated ideas.

Having now presented the analysis and findings of this comparative case study, I now bring the findings from the two components together.

8.5.3 Synthesis of Findings from the two Components

In this section, I bring together the findings from the F2F and the virtual components of this case study. Study 3 was comparative in nature in my quest to identify what is unique about creativity in VDTs. More specifically, focusing on a team that accomplished a task F2F and a task virtually enabled me to unearth (a) factors influencing creativity in a F2F environment, which are transferable to the VDT context; (b) factors influencing creativity in a F2F environment, which are non-transferable to the VDT context; and, most importantly, (c) factors which are unique to the VDT context, which help elucidate the relationship between creativity and virtuality. These factors are outlined in Table 23 below.

Next I reflect on, and discuss the strengths of, this comparative case study.

Table 23: Factors Influencing Creativity in the Industrial Case Study

	Factors non-transferable to the VDT context	Factors transferable to the VDT context	Factors unique to the VDT context
Individual-related Factors		(+) Personal attributes: being technologically savvy and educating others on use of relevant software	(-) Unfamiliarity with selected ICTs : causing interruptions to the creative process
Team-related Factors	(+) 'Chemical reaction' between team members, triggering generation of ideas (+) Physical proximity offering immediate feedback and building on each other's ideas (+) Physical proximity offering an opportunity to prototype ideas , giving rise to more ideas (+) Physical proximity increasing communication speed, engagement levels, enthusiasm & alertness (+) Inherent visibility of the physical environment increasing opportunities for creativity	(+) Good team size, dynamics and respect to each other's ideas (-) High degrees of homogeneity in team composition inhibiting creativity (+) Democratic and strength-based leadership : giving room for all ideas to be heard & utilizing members' skills (+) Accepted central leader for decision making	(+) Geographical dispersion: (a) increases participants' individual sense of ownership and responsibility ; (b) offering flexibility and space for understanding in the early stages of the VDT lifecycle ; & (c) geographical isolated members have less distractions and can be more productive in terms of ideas (-) Geographical dispersion: (a) not allowing for collaborative brainstorming or for ideas' prototyping ; (b) inhibiting use of pen and paper ; (c) raising boundaries; (d) reducing (subconscious) visibility and speed ; & (e) not allowing members to bounce off ideas, get instant feedback , and build on each other's ideas (-) Feelings of isolation inhibiting creativity when members work in isolation throughout the VDT lifecycle

Technology-related Factors		<p>(+) Use of CAD helping participants depict and share their ideas with the rest of the team</p> <p>(+) Individual use of Internet helping participants identify and build on existing ideas</p>	<p>(-) Cost- and ICT-proficiency-related factors influencing ICT selection</p> <p>(-) Artificial character of synchronicity: quality, accessibility and delays</p> <p>(-) Reduced visibility causing uncertainty and impressions of unavailability</p> <p>(-) Asynchronous CMC: slowness interrupting collaborative creative process</p> <p>(-) Synchronous CMC: slowness, time limitations and reduced productivity</p>
Organization-related Factors	<p>(+) Organizational practice: shared wall space for (a) better visualization of ideas; (b) ideas' sharing; and (c) ideas' tracking</p> <p>(+) Organizational focus on the task: unstructured physical work environment enhancing creativity</p>	<p>(+) Organizational approach: freedom & openness improving (a) the understanding of the design task; and (b) the number of ideas</p> <p>(+) Organizational practice: design process of controlled and divergent character</p> <p>(+) Organizational focus on the task: lack of paperwork & peripheral activities</p> <p>(-) Unexpected absences causing changes in the direction of the project</p>	

8.6 Reflection on, and Strengths of, Study 3

Study 3 built on the lessons learned from the previous two studies and furthered knowledge in the field in a number of ways, discussed below:

First, I used the same, improved methodological approach I adopted for Study 2 in the previous chapter in a different context, the industrial. Therefore, the most noticeable strength of this study is that it involved professional designers working for a real UK-based SME on two customer-driven projects. Hence, further to expanding knowledge in the field by examining VDT creativity in the industrial context—given that literature on VT creativity has been conducted predominantly in educational settings (e.g. Chang, 2011; Martins and Shalley, 2011; Ocker, 2007b)—this study may also be of value to practitioners, whose work is accomplished in VT environments and requires creativity, in the field of design and beyond.

Second, consistent with the aims of the thesis, and similarly to the previous two case studies, Study 3 contributes an improved understanding of where creativity is positioned within the VDT lifecycle, which was achieved through analysis of the video recordings in the virtual component of this study. My findings also hint at factors influencing creativity in the industrial VDT context, and also differentiate between (a) factors influencing creativity in F2F environments, which are transferable to the VDT context; and (b) factors which are not transferable to the VDT context. Most importantly, though comparison was not aimed between the F2F and the virtual component of the study (e.g. due to inherent differences in the two projects), this comparative element of Study 3 helped to isolate factors influencing VDT creativity that are uniquely related to the issue of virtuality. Thus, these factors promote an understanding of the relationship between creativity and the unique characteristics of virtuality in the industrial VDT context, which the extant literature has so far neglected.

Third, the robust methodological approach adopted in this study involved interview data, non-participant observations (in a logbook and recorded), video data, written communication extracts, design outputs, and other materials produced by the team. Though, therefore, as I have argued repeatedly in the thesis, these different datasets

were not gathered for triangulation purposes, they reduce the limitations of each of these methods when used individually and provide a rich picture of the context in which the team operated.

Fourth, inevitably the team that was examined in this study was different to the ones in the previous two studies. For example, the participants here were highly homogeneous (e.g. mother tongue, education), the team was not global but national, and the participants were geographically isolated from one another with no locational subgroups being formed. Despite the limitations emanating from these differences, there are a number of advantages too. For instance, this study builds on previous literature—arguing that VTs comprising geographically isolated members preform better than VTs involving subgroups (O'Leary and Mortensen, 2010)—by exploring whether these findings have implications for creativity.

8.7 Onward

Thus far, I have presented three case studies that were conducted for the purpose of addressing the aims of the present thesis. I have briefly reflected on each case study and outlined their strengths at the end of each empirical chapter, explaining how each study built on the previous one. In the next chapter, I describe the VDT context of this thesis, and discuss the thesis' theoretical contributions through synthesis of the findings.

Chapter 9: Discussion

I commence the chapter by presenting a new typology of Virtual Design Teams (VDTs), highlighting the context within which the different case studies were conducted. Subsequently, I synthesize the findings across the three case studies and return to the literature in order to explain the theoretical contributions of the thesis, primarily to the literature on Virtual Teams (VTs). The chapter closes with a discussion of the factors that were found to specifically relate to the design context.

9.1 A Typology of the Thesis' Virtual Design Teams

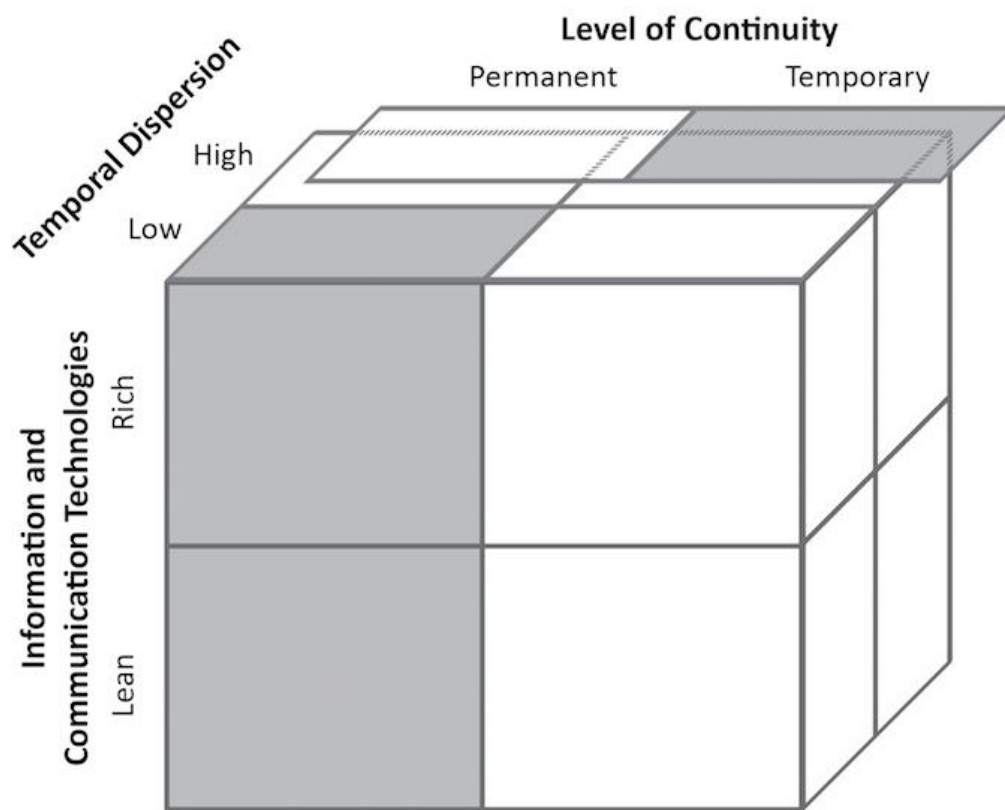


Figure 42: An Emergent VT Typology highlighting the VDT Context of the Thesis

I argued earlier in 2.4 that not all VTs, and by extension VDTs, are the same (see Table 12, p. 126 for details). Consistent therefore with recent Information Systems (IS) and management research on issues of theoretical sampling (Urquhart and Vaast, 2012) and on the role of case studies (Eisenhardt and Graebner, 2007), discussed in 5.3, I draw together the similarities of the three case studies—

similarities at both the team/conceptual level and the analytical approach—in order to make associations between emerged and existing concepts and deepen theory in the field of creativity in VDTs. These similarities give rise to a VT typology (Figure 42) that adds to existing ones. For example, Panteli (2004b) discerns different types of VTs based on their level of continuity, relationship to the organization, and degree of geographical dispersion. Similarly, Griffith *et al.* (2003) identify three different VT types (traditional, pure virtual, hybrid) based on physical distance among members and level of technological support. The typology that emerges from my thesis uses the level of continuity (permanent vs. temporary) proposed by Panteli (2004b) and also presents a clearer picture of Griffith *et al.*'s (2003) level of technological support, by classifying the Information and Communication Technologies (ICTs) used per their level of richness (Dennis and Kinney, 1998).

The VDT characteristics that led to this typology are detailed as follows: be it for 24 hours, two weeks, or a few months, all VDTs under study were assembled for a single design task and subsequently disassembled, thus being classified as temporary VDTs regarding their level of continuity (Panteli, 2004b). Temporal dispersion (e.g. Bell and Kozlowski, 2002; Martins *et al.*, 2004) was low in all VDTs, varying from 0 (Study 3) to 1 hour of difference (Studies 1 and 2), thus not raising significant (if any) implications. With regard to the media richness theory (Dennis and Kinney, 1998), all teams used a combination of both asynchronous (lean) and synchronous (rich) ICTs as they considered appropriate. The characteristics that describe the VDTs under study are highlighted in grey colour in Figure 42 above. In addition to these, a final similarity characterizing the VDTs of the thesis concerns their members' degree of familiarity (e.g. Espinosa *et al.*, 2003)—a dimension whose relationship with creativity has not been looked at before. My thesis involved teams with *some* degree of familiarity, contrary to VTs with no familiarity whatsoever (e.g. pure virtual teams), whose members have no(t had) physical contact (Griffith *et al.*, 2003). The degree of familiarity evidenced in the teams was attained through (a) some Face-to-Face (F2F) work that occurred at some point within the VDT lifecycle (i.e. in the last phase of the European Global Product Realization (EGPR) in Study 1); (b) partial F2F work within physically collocated subgroups (i.e. Studies 1 and 2); or (c) prior F2F

work (i.e. Study 3). Further to the similarities at the team/conceptual level, there are similarities in terms of the analytical approach adopted; most notably, the same data analysis methods were used for all case studies.

9.2 Theoretical Contributions

The thesis assumed that creativity in the VDT context may be different to creativity in any other (VT or traditional/F2F) context and sought to address the following Research Question (RQ):

How is creativity influenced in temporary Virtual Design Teams (VDTs)?

The three case studies I conducted succeed in addressing this research question and contribute to the theoretical framework (Figure 13, p. 82) differently, due to differences characterizing the different teams under study. For example, Studies 1 and 2 showed how heterogeneity influenced creativity, due to their multicultural character, whereas Study 3 contributed organizational factors due to its industrial character. Overall, I argue that the thesis makes the following theoretical contributions: (a) it advances our understanding of creativity within the temporary VDT lifecycle; (b) it elicits a set of factors influencing creativity within this context; and (c) it explains how the unique characteristics of virtuality influence creativity. I discuss these contributions in the sections that follow.

9.2.1 Understanding Creativity within the VDT Lifecycle

The literature on VTs argues that the VT lifecycle (a) is different to a traditional, physically collocated, team's lifecycle; (b) features as one of the VTs' unique characteristics; and (c) raises important implications for VT management and leadership (Bell and Kozlowski, 2002). My thesis represents one of the few research studies that have looked into VT projects from initiation to termination and succeeds in advancing understanding of creativity within the VDT lifecycle in particular.

The thesis offers three figures illustrating how creativity fluctuated over time (Figure 22, p. 145; Figure 31, p. 195; and Figure 41, p. 258) in the three case studies respectively. The first is based on my interpretation of the views of the participants in Study 1, and the last two emerged from an ideas count which I performed based on observations and analysis of videos and other material. Clearly, the three lifecycles emerging from the three case studies cannot be shown together in one diagram, due to differences in terms of duration and structure of each team's

lifecycle. For example, the VDTs in Study 1 had a predefined design process to undergo, while the VDT in Study 2 was characterized by freedom and flexibility and therefore the participants in it followed a more flexible approach in terms of stages and activities throughout the challenge. The VDT in Study 3, on the other hand, did not involve prototyping or delivery of a physical product, as in the other two cases. Despite these differences, four distinct stages of the VDT lifecycle emerged from my analysis of the three case studies. In what follows, I present these stages and discuss how creativity fluctuated throughout the VDT lifecycle, emphasizing what is unique about the relationship between creativity and virtuality. In particular, I focus on how creativity in VDTs may be different to creativity in (a) collocated design teams and in (b) other VT contexts. I lastly juxtapose the identified stages and findings within them with other studies that have looked into the VT lifecycle.

Launch and Early Stages

Hertel *et al.* (2005) suggest that the initial stages of the VT lifecycle, involving preparations and launch, are crucial. It has also been argued that a F2F meeting may be necessary in the early stages in order for trust to develop early on in the lifecycle (e.g. Duarte and Snyder, 1999; Nandhakumar and Baskerville, 2006). All VDTs studied here experienced some level of F2F collaboration prior to initiation of the projects. For example, the participants in the same locational subgroups within the teams of Studies 1 and 2 knew each other, while the participants in Study 3 shared working history on a F2F project prior to the virtual one. Thus, though the participants did not conduct a F2F meeting at initiation of these projects, it may be argued that some level of trust had been developed otherwise. My findings highlight that information clarity is critical early on in the VDT lifecycle in order for the teams to select a task they understand and feel happy with. Though this was the case with Studies 1 and 3, certain participants in Study 2 missed large part of the kick-off virtual meeting due to technical and language issues, which resulted in them misinterpreting the brief and choosing a design task that did not live up to their expectations. However, extensive discussions with the French subgroup and ESTIA24 organizers in Study 2 during one of the early Video-Conference (VC) meetings helped the UK subgroup to gather as much information as possible regarding the design task once it had been selected.

Thus, availability of synchronous ICTs at that stage was crucial for understanding the task.

Understanding and Researching

While the participants had started to make sense of their design task, they typically started to research what is available on the market. Research was done individually and also in team situations and was what guided the VDTs' following steps (1st quote, p. 147) and gave rise to more ideas later on, when the participants had to generate ideas themselves. Virtuality at that early stage acted as an enhancer, as it gave the participants the freedom and flexibility to do both further understand the design task at hand, and conduct their research independently with minimal distractions (2nd quote, p. 266); thus, further to isolated members being more productive (O'Leary and Mortensen, 2010), they were also found to be more creative at that stage. Moreover, technology at that stage did not raise any problems for the participants' creativity as it was used for research and not for collaboration purposes. Therefore, at that stage the influence exerted by virtuality was mostly positive.

Conceptual Stage: Generating Principle Solutions

Moving onto the conceptual phases, where the participants had completed their research and were expected to start generating and sharing ideas, I found that the role of the individual was instrumental. Ocker (2005) claims that stimulating colleagues are necessary for creativity in VTs. My findings suggest that indeed participation of stimulating and motivated individuals are necessary at the early stages in particular; they can enhance the VDT's creativity significantly by either urging their teammates to be more creative or by assuming a leadership role and enquiring about their teammates' feedback and input as well as planning the next steps. According to the design literature, creativity in traditional design teams is notably higher in the conceptual phase when designers are expected to generate principle solutions (e.g. Cross, 2008; Hill, 1998; Howard *et al.*, 2008). Indeed, the findings from all three case studies show evidence that this is still the case in the VDT environment. In fact, most concept ideas were generated at that stage. While in the

F2F project of Study 3 the team used a shared wall surface to present and share their ideas, facilitating the creative process significantly (Figure 39, p. 245), the VDTs in my thesis went through that phase using ICTs. The general preference, and given that temporal dispersion was minimal (if any), across the different teams was for synchronous ICTs that would enable simultaneous brainstorming and sharing. Though synchronous ICTs were used for coordination purposes to a large extent (mainly in Studies 1 and 2), it was found that they enhanced creativity significantly as they were seen as a unique opportunity by the VDTs to *get together* and be collaboratively creative (5th quote, p. 163). Other factors contributed to the general preference for synchronous ICTs. For example, the short lifecycle of the VDT in Study 2 (24 hours) did not allow for extensive use of asynchronous ICTs as they would be distracting and time consuming (1st quote, p. 214). However, asynchronous ICTs provided unparalleled benefits for creativity. For instance, the participants in Study 1 found that they enabled them to be creative as a team when their teammates were unavailable (1st quote, p. 164). The idea counts I performed provide evidence that despite problems that were introduced by the ICTs used and other issues discussed later, creativity was significantly higher in the conceptual stages in all teams, consistent with prior works based on traditional design team environments. Furst *et al.* (2004) argue that clashes may emerge in heterogeneous VTs early on in the VT lifecycle. In the VDTs of this thesis, it was observed that these become apparent at the conceptual phase when diversity in terms of generated ideas may be owed to different backgrounds.

Later Stages: Element Ideas and Prototyping

Once most concept ideas were generated for all teams, the participants continued to generate ideas, but these were mostly element ideas, e.g. concerning aesthetics, materials and properties, functions, costs, and practicalities. Thus, though creativity was not equally high at that stage, the teams were creative through to the later stages. Individual use of technology (e.g. Computer-Aided Design (CAD)) helped the participants to visualize their former ideas and explore emergent problems and findings, which again gave rise to more ideas through discussion. However, at that stage, ICTs inhibited the teams' creativity by not allowing for real-time feedback,

which, in the F2F project, was found to be instrumental for creativity. Though the participants in Studies 2 and 3 were exclusively engaged with the projects at hand throughout the VDT lifecycle (with the exception of Geoff in Study 3), this was not the case in Study 1, in which the participants had other commitments as well. It was at that stage when the EGPR participants were expected to be creative but could not devote much time, as other commitments had to take priority. Further, given the inter-university dimension of the VDTs in Study 1, different universities valued the EGPR differently, influencing the participants' motivation and creativity negatively. This is important because it foreshadows that different commitments and priorities may influence creativity in inter-organizational VDTs in industry.

It was also observed that creativity rose significantly again during the prototyping stages, when the participants—be it in a F2F environment (Study 1) or within a locational subgroup (Study 2)—came across unexpected problems and issues which enhanced their creativity. Such instances were recorded in both the VDTs studied in Studies 1 and 2 (e.g. 1st quote, p. 149) and in the F2F project of Study 3, but it was not the case in the VDT of Study 3. One can argue that the VDT in Study 3 did not have the chance to prototype their ideas due to its members being geographically isolated from one another throughout the VDT lifecycle, which seemed to have been agreed prior to the project (observation extract, p. 255). It follows therefore, that further to studies arguing for the need for a F2F component early on in the VT lifecycle in general (e.g. Duarte and Snyder, 1999; Nandhakumar and Baskerville, 2006), a F2F component is also needed in the later stages in the case of VDTs, as it may reveal problems which the VDTs have not been able to predict before, and which give rise to more ideas. Thus, virtuality in cases of VDTs whose members are isolated throughout the lifecycle may act negatively for creativity, by not allowing their members to prototype as it happens in collocated design teams. However, though this may be attributable to the design context used in this thesis, having F2F collaboration at the later stages of the VT lifecycle may also be of value to VTs in other contexts.

My thesis builds on previous studies that have looked into the VT lifecycle. For example, it expands Nemiro's (2007) four stages of the creative process—idea

generation, development, finalization/closure, evaluation—by identifying the stages of the VDT lifecycle that are relevant in the design context. Further to interventions VT managers can make to improve VT performance at each stage of the VT lifecycle based on an empirical study (Furst *et al.*, 2004) and the stages found and activities performed during the VT lifecycle based on an analysis of existing studies (Hertel *et al.*, 2005), my thesis contributes to this literature by positioning creativity and its different types within the VDT lifecycle, and by unpacking what is unique about the relationship between creativity and virtuality within it, in particular in comparison with collocated design teams as well as VTs in different contexts (e.g. Nemiro, 2007).

Moreover, by looking into the VDT lifecycle from start to finish, I overcome another limitation found in the extant literature. Much of the literature on creativity is based on quantitative, snapshot research paradigms stemming from the natural sciences. These seek to test made hypotheses or identify causalities between certain factors and certain situations, and inevitably remove the dynamism encountered in organizational contexts (Markus and Robey, 1988). Isolating single factors from organizational processes that involve human activity, and developing factor-models may not be germane to the study of VTs (Clear, 2009), where organizational processes are shaped through the interaction of actors and events (Newman and Robey, 1992). By positioning creativity within the VDT lifecycle, my thesis overcomes the aforementioned limitation encountered in most factor-based studies by identifying factors that can be understood better in relationship with the VDT lifecycle.

In Table 24 below I outline the phases of the VDTs' lifecycles, and I show how the predefined phases of the EGPR (based on Figure 22, p. 145) and also the phases emerging from the time-based analyses of Studies 2 and 3 (based on Figures 31, p. 195; and 41, p. 258) relate to the four phases I discussed in this section. I also provide key findings that highlight what is unique about the relationship between creativity and virtuality throughout the VDT lifecycle. Subsequently, I proceed to the second and third contributions, which take a closer look at the factors influencing creativity and the role played by the unique characteristics of virtuality respectively.

Table 24: Creativity in the VDT Lifecycle

	Launch and Early Stages	Understanding and Researching	Conceptual Stage	Later Stages
Study 1 (Figure 22, p. 145)	EGPR Phases 1: Market Research		EGPR Phase 2: Conceptual Design	EGPR Phases 3 and 4: Design Finalization and Assembling and Presentation
Study 2 (Figure 31, p. 195)	Task Analysis Phase (hours 13:00 – 17:20)		Conceptual Design Phase (hours 15:15 – 05:20)	Product Development Phase (hours 00:30 – 13:00)
Study 3 (Figure 41, p. 258)	Early Stages: Launch and Organization (Day 11)	Ideas' Generation, Sharing and Computer-Aided Design (CAD) (Days 12 – 20)		Non-applicable
Creativity and Virtuality	<p>F2F meeting may not be necessary if there is some level of trust among VDT members</p> <p>Information clarity is needed in order for the VDT to select a pertinent task (Study 2) and to be able to make sense of it</p>	<p>Synchronous ICTs can enhance understanding of the design task by bringing the VDT together with organizers</p> <p>Isolated members perform more creatively as they are given the time and space to understand the design task at hand and perform research independently</p>	<p>ICTs create boundaries and slow down the creative process at the team level</p> <p>Both synchronous and asynchronous ICTs have the potential to enhance creativity</p> <p>Isolation inhibits creativity, exacerbates the negative effects of heterogeneity and dispersion</p> <p>Heterogeneity brings more ideas to the table</p>	<p>Use of ICTs and CAD should be such that it allows for quick feedback and creativity</p> <p>Different priorities in inter-organizational VDTs influence members' motivation and creativity</p> <p>F2F collaboration for prototyping purposes gives rise to more problems and ideas</p>

9.2.2 Elicitation of Factors influencing Creativity in Temporary VDTs

My main criticism of the VT literature has been based on the assumption that little is known about creativity in VT settings. One of the thesis' aims was therefore to elicit factors influencing creativity as a means for enabling a better understanding of creativity. My thesis unpacked factors relating to the individual, the team, the task and the organization, which expand prior findings emanating from both the creativity and VT literatures.

Individual-related Factors

The traditional creativity literature highlights that all individuals have the potential to be creative in one domain (Kirton, 1994; Stenberg, 1999). It also offers capacities (e.g. expertise) and capabilities (e.g. defining problems) that enable individuals to be creative (Mumford *et al.*, 2007). Most scholars are also agreed that creativity at the individual level relates to cognitive factors, personality traits, relevant knowledge, and motivation (e.g. Amabile, 1998; Andriopoulos and Dawson, 2009). Within the VT literature, it has been argued that assertiveness, ideas and anxiety are personality facets enhancing creativity, whereas achievement features as an inhibitor (Ocker, 2007b). My findings both corroborate that some of the factors found in the traditional creativity literature are still significant within the VDT context, and extend prior work by eliciting specific factors that were found to matter in the context of this thesis.

Despite the recognition that certain individuals were more creative than others (1st quote, p. 153), my findings highlight that good communication and organizational skills were critical for creativity. Good communicators and those showing initiative were able to overcome problems of language difference and heterogeneity and show their creativity using alternative ways, e.g. using their hands on the VC. Further, motivation and knowledge (Amabile, 1998) were found to be of paramount importance. On the one hand, motivated individuals were the ones who also took the initiative, inquired more, understood the project better and contributed to their team's leadership, driving the projects forward. Motivation was also related to engagement levels; those with low engagement levels, for example, were not found

to contribute to the VDTs' creativity satisfactorily (quote, p. 209). On the other hand, my findings show support to Staw's (2009) argument that knowledge and training are instrumental for creativity. Study 1 demonstrated that individuals are more creative within their area of expertise. For instance, knowledge emanating from industrial designers' education led to higher creativity in terms of presentation purposes, whereas mechanical engineers were more creative in solving problems (3rd quote, p. 155).

In all, the findings at this level demonstrate that there exist factors from the traditional creativity literature (e.g. motivation, knowledge) that are still relevant in this context, and, more importantly, paint a picture of the creative individual by building on Ocker's (2007b) findings (e.g. assertiveness). In particular, my thesis suggests that individuals must be keen and creative communicators with high levels of motivation and engagement, initiative-takers, and have relevant (education- and experience-related) knowledge in their domain.

Team-related Factors

Creativity is largely seen as a team activity in the literature (Csikszentmihalyi, 1996; Osborn, 1957; West, 1990). Team creativity is influenced by the team's composition, characteristics and processes (Woodman *et al.*, 1993). Others argue that the creativity at the team level introduces challenges as well, such as illogical behaviours and social loafing (Thompson, 2003). Though several factors have been posited in the traditional creativity literature (e.g. heterogeneity (Cummings and Kiesler, 2007)), our understanding around how these might influence creativity in a VT environment is limited. My findings address this gap by explaining how heterogeneity and leadership—two known factors in the traditional literature, which also emerged in my analysis—influence creativity in the VDT context. Current VT literature has attempted to explore how issues relating to heterogeneity—such as demographical differences (Chang, 2011; Martins and Shalley, 2011)—may influence creativity or what the different e-leadership styles found in VTs are (e.g. Chamakiotis and Panteli, 2010), yet these studies do not explain how heterogeneity or leadership influences creativity within the VT context.

Varying degrees of heterogeneity were posited in the different VDTs under study, with Studies 1 and 2 comprising the most heterogeneous teams. Overall, it was found that some heterogeneity is necessary as highly homogeneous VDTs may find that they are not creative enough, because all members address an issue from a similar angle (1st quote, p. 248). On the other hand, in highly heterogeneous VDTs, it was found that creativity was high because of the diverse educational backgrounds and perspectives to a problem (2nd quote, p. 157). However, my findings suggest that heterogeneity may also lead to misunderstandings and misconceptions, slowing down the creative process significantly (1st paragraph, p. 202). These findings add to the literature on creativity arguing that high levels of heterogeneity in teams can have a positive influence on creativity (e.g. Amabile, 1998; Woodman *et al.*, 1993), corroborating the importance of having some heterogeneity in VDTs, as long as misunderstanding emanating from heterogeneity do not interrupt the creative process. Further, heterogeneity in terms of education led to difficulties explaining the rationale behind specific concepts (quote, p. 218). In addition, heterogeneity was also found to be linked to subgrouping, which I discussed later, as it features as one of the unique characteristics of virtuality.

Scholars have posited that leadership in VTs is different to leadership in collocated environments. And though leadership has been discussed in relationship with creativity in the traditional literature (e.g. Mumford *et al.*, 2002), little is known about its relationship with creativity in VTs. With my findings I demonstrate that centred leaders (Kerber and Buono, 2004) are necessary in VDTs, as they ensured that creativity remained high throughout the VDT lifecycle (e.g. Table 14, p. 160; 4th quote, p. 250). Centred leadership was found to be participative, motivational, and democratic (1st quote, p. 250) consistent with the traditional leadership literature (Bass and Bass, 2009). In Study 2, Dylan was both an emergent and centred leader throughout the team's lifecycle, and he and Frank (from the French subgroup) acted as the two main communication facilitators, in line with the wheel approach (Nemiro, 2007). Also of significance were found to be models of emergent and shared/collaborative leadership. Similar to previous VT literature (e.g. Avolio *et al.*, 2000; Chamakiotis and Panteli, 2010), arguing for the importance of these styles for

VT effectiveness, the data suggest that leadership should be exercised in a collaborative manner based on the VDT participants' strengths and expertise (e.g. quote, p. 249). Carte *et al.* (2006) suggest that VTs in which e-leaders have emerged perform better than others. Similarly, in the case studies presented here emergent leadership was found to be an enhancer for creativity, as it was seen as a response to the assigned leader's occasional unavailability (e.g. Table 14, p. 160).

Task-related Factors

The concept of the task has a prominent position within the VT literature as it is what brings a VT together in the first place (Townsend *et al.*, 1998). Powell *et al.* (2004) also argue that VT members should select ICTs that fit their assigned task, while Cropley (2000) suggests that individuals must be fascinated by their assigned task in order to be creative. However, the design literature suggests that not all tasks require the same degree of creativity (Gero, 2001). While the teams in Studies 1 and 3 were happy with the designs they were tasked with, this was not the case with some participants in Study 2. The latter were given the chance to select a design they felt happy with, yet insufficient information and communication issues early on in the VDT lifecycle led the team to select a task they were not happy with. Consequently, their decision created feelings of disappointment and was found to inhibit creativity, mainly because it was felt that the selected task did not match their skills (quotes, p. 207).

Organization-related Factors

The literature (a) argues that the organizational environment has an important role to play for creativity as it is what brings the individual and the team creativity together (e.g. Paulus, 2000); and (b) identifies a number of factors that influence creativity at the organizational level, such as resources, organizational culture and climate (Andriopoulos, 2001). Admittedly, Studies 1 and 2 were conducted in educational settings, thus not allowing for the study of organizational factors influencing creativity. Yet, these studies still foreshadow factors relating to the environment. For example, though the VDTs in Studies 2 and 3 were concentrated on a single task throughout the VDT lifecycle, the participants in Study 1 were

engaged in other tasks too. As such, in Phase 3, when the mechanical engineers in the EGPR were expected to take over from the industrial designers and be creative, other commitments inhibited them from being as creative as they could have been. These findings suggest that VDT members who participate in multiple VTs in organizations may not be able to show their creative potential to its maximum. Similar issues were also observed in Study 3 when Geoff became unexpectedly absent, influencing the project's direction and creativity (emails, p. 265).

Study 3 was conducted in an industrial setting, and thus, adds to our understanding of organizational factors. Through comparison of a F2F and a virtual project in Study 3, my findings reveal that not all organizational factors found to influence creativity in the F2F project were transferable to the VDT context. For example, Alpha employees make use of a shared wall space at Alpha's physical offices, as part of the design process when working F2F. Though this was evidenced in the F2F project (Figure 39, p. 245), and despite use of relevant ICTs, the participants in this study were not able to create a similar space which would allow them to visualize, share, and/or track their ideas in a similar manner when working virtually. On the other hand, however, issues of organizational philosophy and approach (Andriopoulos, 2001) about (a) openness when generating ideas (1st quote, p. 242), or (b) the fact that Alpha employees are not preoccupied with peripheral tasks that may influence their creativity negatively (1st quote, p. 246), were found to be transferable to the VDT context. My findings at the organizational level also highlight differences in creativity in VDTs in the design context from creativity in VTs in other industries. Chamakiotis and Panteli (2009) suggest, in their study of a global virtual organization in the advertising industry, that despite the importance of creativity within the organization under investigation, other issues may take priority at the later stages of a project, inhibiting creativity significantly. In the VDT context, however, creativity was found to be equally important throughout the VDT lifecycle.

These findings contribute to theory by showing which factors influence creativity in the context on VDT. They do so by both confirming findings emerging from the traditional creativity literature (e.g. Amabile, 1998) and identifying factors that are significant in any context (virtual or collocated). They also build on prior work on VTs.

Though prior work (Chang, 2011; Letaief *et al.*, 2006; Ocker, 2005) has contributed similar factors, they are based on educational settings in which the VTs under study were put together for the purposes of the studies and are either monocultural or use asynchronous ICTs only (Chang, 2011; Ocker, 2005), which is not usually the case in VTs in industry. Thus, with my thesis I contribute to the extant literature by providing findings that are based on VDTs that are multicultural (Studies 1 and 2) and use both asynchronous and synchronous ICTs to accomplish their tasks. My findings suggest that the factors relate to the individual, the team, the task and the organization, and are classified as enhancers and/or inhibitors with varying levels of influence (minor vs. major). Furthermore, by considering different levels of creativity (as discussed above and shown in Table 25 below, in which all factors are summarized), my thesis contributes to the individual-team-organization framework (Figure 11, p. 57; Chen, 2006; Thatcher and Brown 2010) which has not been systematically studied in any VT context before, despite its dominant position within the traditional creativity literature. Finally, these findings hint at potential contributions to the field of design (e.g. extending Monalisa *et al.*'s (2008) study), which in this thesis has been used as an empirical context, by explaining in more depth how the individual or the organization influence creativity.

Table 25: Factors Influencing Creativity in temporary VDTs*

	Key Factors emerging from the Literature	Enhancers of Creativity		Inhibitors to Creativity	
		Major	Minor	Major	Minor
Individual	<p>Capacities (expertise, creative thinking skills, social skills, organizational knowledge) and</p> <p>Capabilities (defining problems, establishing context, development and fielding) (Mumford <i>et al.</i>, 2007)</p> <p>Cognitive factors, personality traits, relevant knowledge, motivation (Andriopoulos and Dawson, 2009; Amabile, 1998; Csikszentmihalyi, 1997)</p> <p>Assertiveness, ideas, anxiety, achievement (Ocker, 2007b)</p> <p>Dominance (Ocker, 2005; 2007a)</p>	<p>Participation of creative individuals: one or two in each VDT</p> <p>Relevant knowledge: education- & experience-related</p> <p>Communication skills: oral & creative</p> <p>Personal attributes: inquiring mind</p> <p>High motivation and engagement levels</p> <p>Personal attributes: being technologically savvy and educating others on use of relevant software</p>	<p>High task engagement: showing initiative</p> <p>Organizational skills: coordinating the VDT</p> <p>Good understanding of the project</p> <p>Leadership potential: driving the project forward without conflict</p>	<p>Lack of team spirit: undertaking tasks without consulting with the rest of the VDT</p> <p>Unfamiliarity with selected ICTs: causing interruptions to the creative process</p>	<p>Lack of initiative: being a silent designer</p>

Team	<p>Group composition, characteristics and process (e.g. Woodman <i>et al.</i>, 1993)</p> <p>Heterogeneity (e.g. Cummings and Kiesler, 2007)</p> <p>Leadership (e.g. Mumford <i>et al.</i>, 2002)</p>	<p>Centred leadership: coach responsibility from start to end (participative & motivational)</p> <p>Heterogeneity: knowledge sharing; new ideas; germane distribution of tasks</p> <p>Shared/Collaborative leadership: leading based on strengths/expertise</p> <p>Democratic and strength-based leadership: giving room for all ideas to be heard & utilizing members' skills</p>	<p>Emergent leadership: allowing & encouraging new leaders to emerge during the VDT lifecycle</p> <p>Good team size, dynamics and respect to each other's ideas</p> <p>Accepted central leader for decision making</p>	<p>Stronger voices: not allowing all ideas to be heard; disappointment</p> <p>High degrees of homogeneity in team composition inhibiting creativity</p>	<p>Heterogeneity: misinterpreting concepts & ideas</p>
Task	<p>VT members must be fascinated by the task in order to be creative (Cropley, 2000)</p> <p>Varying levels of creativity characterizing different design tasks (Gero, 2001)</p>			<p>Insufficient information on design task (a) different interpretations; and (b) unclear expectations</p> <p>Design task unrelated to the participants' expertise</p>	<p>Design task simplicity</p> <p>Design task vagueness</p> <p>Design task contradictions</p>

Organizational	<p>Organizational culture, climate, resources and skills, structure, pressures, and socio-technical systems (Andriopoulos, 2001; Csikszentmihalyi, 1996)</p> <p>Challenge and involvement, freedom, trust and openness, idea time, playfulness and humour, conflict, idea support, debate, and risk-taking (Isaksen and Lauer, 2001)</p>	<p>Organizational approach: freedom & openness improving (a) the understanding of the design task; and (b) the number of ideas</p> <p>Organizational practice: design process of controlled and divergent character</p> <p>Organizational focus on the task: lack of paperwork & peripheral activities</p>			<p>Unexpected absences causing changes in the direction of the project</p>
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* Study 1 findings in blue; Study 2 findings in red; Study 3 findings in green

9.2.3 Creativity and the Unique Characteristics of Virtuality

In this section, I discuss how virtuality influenced creativity in the VDTs under study. The unique characteristics of virtuality that emerged from my analysis are: geographical dispersion/separation; emotions; language; subgrouping; boundaries; technology; Computer-Mediated Communication (CMC); and lastly the issues of synchronicity and asynchronicity. My findings underscore that there exists an interwoven relationship between these characteristics, and each was found to have an enhancing and/or an inhibiting role in creativity under different circumstances. Central to understanding these roles have been the notions of continuities and discontinuities which feature in the recent literature, as I explain below.

Geographical Dispersion/Separation

Geographical dispersion features as one of the most salient characteristics of VTs within the literature, acknowledged in most VT definitions (e.g. Cascio, 2000; Kayworth and Leidner, 2000; Lipnack and Stamps, 1997). My thesis examined cases of both geographical dispersion (between two or more locations) and geographical separation (between two locations only); and is the first to focus on the relationship between geographical dispersion/separation and creativity. In the literature, geographical dispersion is tacitly seen as a troublesome characteristic by scholars, which is inherent in virtual work and raises significant challenges (e.g. Cramton, 2001; Townsend *et al.*, 1998). In view of this, Gibson and Gibbs (2006) studied how geographical dispersion in VTs may influence innovation (not creativity). Their study is a deductive one which assumed and demonstrated that indeed geographical dispersion influences innovation negatively, by generating contextual complexity and weak ties among members. Glier *et al.* (2011) recognize that design teams are geographically dispersed and examine which creativity techniques work better in dispersed team environments.

Unsurprisingly, therefore, my findings show that geographical dispersion inhibited creativity by, for example, reducing teamwork and exacerbating the negative effects of heterogeneity (e.g. 1st quote, p. 157). In fact, these negative effects of geographical dispersion/separation were evidenced in all three studies. It was found,

for example, that much of the idea generation process was being missed (1st quote, p. 212) and that geographical separation led to work duplication (2nd quote, p. 156). Similarly, geographical dispersion was found to significantly inhibit collaborative creativity by, for example, not allowing for the use of commonly used practices, e.g. use of *pen and paper* (2nd quote, p. 267), or by not allowing the prototyping of ideas, which was found to give rise to more ideas, as it is the case in F2F environments (3rd quote, p. 268).

Geographical dispersion was also found to be linked to the emergence of negative emotions in some teams. Scholars within the VT literature have explored emotions in relationship with conflict (Ayoko *et al.*, 2011) and have also looked into the ways they are manifested in a VT environment (Baralou and McInnes, 2013; Glikson and Erez, 2013). In my studies, I posited that geographical dispersion contributed to feelings of isolation, which had implications for the teams' creativity. Isolated members felt that their creativity was not heard by others (5th quote, p. 158) and that they reached a point where their creativity stopped due to their being isolated from their teammates (3rd quote, p. 267).

However, my findings revealed that geographical dispersion/separation acted not only as an inhibitor to creativity, but also as an enhancer. Distance from the main organizers in Study 2 as well as being isolated from one another in Study 3 meant that the participants in these studies were not influenced by distractions—such as pressure by others (3rd quote, p. 212) or social events—and were given more space to think and understand the design tasks at hand, which led to more ideas (2nd quote, p. 266). This, in turn, enhanced creativity further by creating a sense of ownership and responsibility over the ideas generated by certain individuals (1st quote, p. 267). The latter contradicts previous assertions that perceptions of idea ownership and responsibility in both VTs (Letaief *et al.*, 2006) and collocated teams (Kreitner *et al.*, 2002) inhibit creativity. My findings both corroborate and refute the relevance of prior literature (Gibson and Gibbs, 2006) in the case of creativity in VDTs. In particular, though no positive effects of geographical dispersion were found in Study 1, both Studies 2 and 3 provide evidence that geographical dispersion/separation can both enhance and inhibit creativity within this context.

Subgrouping: types, effects and dominance

Subgroups represent collections of individuals within a VT (Panteli and Davison, 2005) and constitute a unique organizational configuration within VTs, whose relationship with creativity has not been explored yet. Panteli and Davison (2005) identify boundaries between collocated subgroups, exerting varying levels of influence on members' performance, while O'Leary and Mortensen (2010) claim that VTs comprising collocated subgroups perform less satisfactorily than VTs comprising geographically isolated members. My thesis involved both teams comprising physically collocated subgroups (Studies 1 and 2) and one team comprising isolated members only (Study 3). However, the findings hint at other types of subgroups that were posited in all studies, i.e. subgroups based on similar background, and subgroups based on a common sub-task. I also identified multidimensional subgroups (Study 2), whereby two subgroups are characterized by multiple differences (e.g. linguistic, educational).

Overall, the influence exerted by subgroups on creativity seemed to vary. On the one hand, subgroups were perceived as discontinuities by the participants, creating feelings of isolation and imbalance within the teams (3rd and 4th quotes, p. 159) and exacerbating heterogeneity (e.g. observation extract, p. 219). Such feelings have been found to inhibit creativity in the extant literature (e.g. Andriopoulos, 2001; Woodman *et al.*, 1993). It was also found that certain locational subgroups had stronger voices and their ideas were the ones heard most (1st quote, p. 159). Ocker (2007a) argues that certain individuals might exert high levels of dominance within a VT, inhibiting creativity at the team level and leading to imbalance. In particular, she identifies the following types of dominance: expert dominance, vying for dominance, extreme dominance. My findings add a fourth dimension—that of subgroup dominance—that may have a similar, if not higher, effect on VDT creativity (5th quote, p. 158). In addition, when subgroup dominance is posited, my thesis refutes the significance of anonymity and opportunity for equal participation that have been previously found to enhance idea generation in CMC environments (Pissarra and Jesuino, 2005). On the other hand, subgroups were also found to enhance creativity, as continuities emerged through them, helping to mitigate the negative effects of

discontinuities. For example, participants in Study 1 found that physical proximity within a locational subgroup mitigates the negative effects of geographical dispersion and facilitates idea sharing (3rd quote, p. 158). Similarly, the epicentre of creativity (where most ideas were generated) was often within a subgroup—be it locational (e.g. Study 2) or emergent based on common characteristics (e.g. Studies 1 and 3).

Boundaries, Technology, CMC and Synchronicity

Boundaries in the VT environment can take multiple forms, such as geographical, organizational, identity, technical, social and cultural (Espinosa *et al.*, 2003; Orlikowski, 2002). Recent studies argue that continuities and discontinuities can be a theoretical lens that contributes a better understanding of boundaries within mediated contexts. According to these recent studies, a boundary is considered troublesome for virtual work only when VT members perceive it as a discontinuity (Watson-Manheim *et al.*, 2011). Further to discontinuities in VTs, continuities may also emerge, which mitigate the negative effects of discontinuities (Dixon and Panteli, 2010). For example, Dixon and Panteli (2010) find that though the inter-organizational dimension—whereby members from different organizations work in the same VT—may be seen as a discontinuity, as boundaries may exist between the culture, identity, and expectations of the different organizations involved, it is likely that a continuity emerge when a shared identity is developed between those members coming from the different organizations and working in the same VT.

My thesis unpacked various different types of boundaries. In Studies 1 and 2, where the VDTs under study were highly heterogeneous, I posited boundaries that were attributable to the teams' heterogeneity. For example, boundaries owed to different educational backgrounds caused discontinuities inhibiting shared understanding (1st quote, p. 216). Similarly, and coupled with culture-related boundaries, the participants in Study 2 found it challenging to understand the rationale behind an idea that was originally proposed by the rest of the team (quote, p. 218). These cultural differences also augmented the perceived geographical distance between the two subgroups in Study 2 (observation extract, p. 219). These findings demonstrate that such boundaries emerging from issues of culture, language and education are perceived as discontinuities and have an inhibiting role to play for creativity in the VDT context. However, continuities also emerged from these discontinuities. For instance, discontinuities caused in Study 1 because of issues of heterogeneity were overcome by physical collocation in the case of locational subgroups (2nd and 3rd quotes, p. 158). Similarly, the linguistic boundaries that were evidenced in Study 2 were overcome with the use of CMC, when, for example,

participants in Study 2 found it easier to describe an idea by acting it out on the Video-Conferencing (VC) system instead of explaining it verbally. These alternative ways of communicating and sharing ideas also inform the communication accommodation theory, arguing for the renegotiating character of language use within culturally heterogeneous groups (Ayoko *et al.*, 2002), by explaining what forms communication might take in a VDT environment for the purposes of creativity. In this case, the ICTs used helped to create a continuity that mitigated the negative effects of the different languages spoken within the team (Figure 36, p. 201).

My findings highlight the complex character of CMC and ICT use within the VDT environment. In general, the issue of technology within the VT literature has been mainly discussed in relationship with communication and collaboration (Han *et al.*, 2011). On the one hand, my thesis has shown that the technical characteristics and capabilities of the media used within the teams have indeed important implications for the participants' creativity. For instance, the ICTs used by the participants in Study 3 caused significant delays that interrupted their creative process when working as a team of three. On the contrary, Skype and Prezi—the main ICTs used by the team in Study 3 for collaboration—were found to be pertinent for dyadic collaboration within the team. On the other hand, however, I found that, further to the ICTs themselves, it is also the individual use of technology that can help VDTs enhance their creativity. For example, by CAD work, the participants in both Studies 1 (1st quote, p. 151) and 3 (1st quote, p. 271) were able to visualize their ideas better, which gave rise to more ideas. Interestingly, the findings from all three case studies highlighted the importance of visualizing generated ideas. For example, the participants in Study 2 acted out the functions of one of their ideas in their effort to communicate to the rest of the team how their idea would address the design problem at hand (Figure 36, p. 201). Insofar as CMC is concerned, though it generally served as a continuity—as it is what enabled virtual work in the VDTs under study despite the geographical distance separating the participants—its role for creativity varied substantially. In what follows, I focus on the different levels of synchronicity afforded by the different ICTs to explain the role played by each for creativity.

Media richness theory posits that the more synchronous a medium, the higher the level of communication richness (Daft and Lengel, 1986; Dennis *et al.*, 2008; Dennis and Kinney, 1998; Schmitz and Fulk, 1991; Shirani *et al.*, 1999; Workman *et al.*, 2003). These scholars argue that ICTs can be categorized according to their level of richness from lean (asynchronous) through to rich (synchronous) ICTs, and explain how differences in bandwidth can have an effect on performance in mediated environments. In particular, Shirani *et al.* (1999) compared the effects of the level of synchronicity on idea generation, focusing on emails and a Group Support System (GSS).

My thesis contributes a better understanding of how CMC, and the more or less synchronous ICTs used by the VDTs in particular, influence creativity. All teams under study made use of both synchronous and asynchronous ICTs. Asynchronous ICTs were found to enhance creativity in the VDTs of Study 1, in which the participants were dispersed across different locations and affiliated to different universities. Asynchronicity in this case helped the participants record and share their ideas regardless of their teammates' availability, thus providing a unique opportunity for team creativity that cannot be found in collocated environments (1st quote, p. 164). In Study 3, it was observed that asynchronicity was only useful for recording and keeping track of the creative process throughout the VDT lifecycle. In Study 2, asynchronicity was not found to have any enhancing role, due to the very short lifecycle of the team. Despite these benefits of asynchronicity, there is evidence in all case studies that asynchronicity acted as an inhibitor to creativity; it was distracting due to the additional work involved in uploading documents, and because it interrupted the creative process (2nd quote, p. 164).

Synchronous ICTs, on the other hand, such as the VC systems used in Studies 1 and 2 had some positive influence on creativity. For example, participants in Study 1 showed higher levels of commitment and a more responsible approach to creativity during the VC sessions (4th quote, p. 163). These were also seen as an opportunity for *getting together* in a virtual environment and being collaboratively together. However, no similar evidence was found in Studies 2 and 3, where synchronicity was mostly considered troublesome. Interestingly, the data from all studies highlighted

the artificial environment created by synchronous ICTs, either by missing the visual dimension of F2F communication (2nd quote, p. 162), imposing a fixed position for participants, whereby they had to take turns in order to be able to share their ideas (2nd quote, p. 214), or by reducing communication speed and creating interruptions to the creative process (2nd quote, p. 276). However, it must be noted that although these technologies (e.g. VC, Skype) can all be classified as synchronous, they can also be characterized by varying levels of bandwidth with varying implications for the participants' creativity. For example, although the participants in Studies 1 and 2 used, in the main, VC system (thus, ICTs with both video and audio capabilities), the participants in Study 3 used predominantly audio communication via Skype. As a result, the former were able to use their hands in order to share and be creative collaboratively (e.g. 2nd quote, p. 254), whereas the latter were limited to the use of a software program (i.e. Prezi) which they had to use in order to draw up their thoughts.

Whether synchronous or asynchronous, CMC created discontinuities, inhibiting the teams' creativity significantly. For instance, even when communication was synchronous (e.g. on Skype or VC), it was found that the *chemical reaction* that characterizes F2F communication—triggering the generation of ideas and allowing team members to build on each other's ideas—was largely absent. However, the findings demonstrate that it is not always the medium *per se*, but its use by the participants that defines its role and type of influence, as we saw with the EGPR. Further, CMC raised important boundaries impacting the levels of clarity and visibility over each other's work within the VDTs (e.g. Table 18, p. 199). By extension, these boundaries created impressions of absence and unavailability (e.g. emails, p. 265) within the teams, which, again, had a negative impact on creativity. It has to be mentioned, however, that none of the teams studied in this thesis used modern ICTs, such as virtual whiteboards (Smith and Blanck, 2002), that have been found to be pertinent in VTs. Thus, it is likely that if other ICTs had been used by the teams, they would not have been acted as major inhibitors to creativity, as they would have possibly allowed for more synchronous and more collaborative idea generation within the VDT environment, overcoming problems of speed and slowness

characterizing the synchronous ICTs used in the context of this thesis (e.g. 3rd and 4th quotes, p. 276).

In this section, I have explained how virtuality influenced creativity in the VDTs of this thesis, by focusing on the role played by the unique characteristics of virtuality that emerged in my analysis. Contrary to prior similar work (e.g. Gibson and Gibbs, 2006), I did not make *a priori* hypotheses as to which characteristics are significant for creativity in this context or what type of influence they exert. Rather, I allowed the data to show what is important. In all, the discussion above demonstrates that (a) certain characteristics (e.g. subgroups), all of which are outlined in Table 26 below, influence creativity in the VDT context, and (b) their type and level of influence may vary. Thus, my findings contribute to theory by explaining how each of the aforementioned unique characteristics of virtuality can influence creativity within the context of temporary VDTs. More importantly, these are best understood when considered in relationship with the VDT lifecycle. Finally, by considering the discontinuities and continuities that emerged in the case studies, my thesis advances understanding of the relationship between creativity and these notions. While, for example, boundaries that were perceived as discontinuities related to issues of heterogeneity in Studies 1 and 2, in Study 3 these were mostly associated with the use of technology.

Table 26: Virtuality-related Factors Influencing Creativity in temporary VDTs*

	Enhancers of Creativity		Inhibitors to Creativity	
	Major	Minor	Major	Minor
Geographical Dispersion / Separation	<p>Geographical separation between University A and ESTIA24: lack of direct pressure by organizers leading to more creativity</p> <p>Geographical separation between University A and ESTIA24: absence from ESTIA24 social events and temptations helped the subgroup remain more focused</p> <p>Geographical dispersion increases participants' individual sense of ownership and responsibility</p>	<p>Geographical dispersion offering flexibility and space for understanding in the early stages of the VDT lifecycle</p> <p>Geographical isolated members have less distractions and can be more productive in terms of ideas</p>	<p>Geographical dispersion: reducing teamwork; exacerbating participants' differences</p> <p>Geographical separation between the two subgroups: idea generation process being partially missed</p> <p>Geographical separation between the two subgroups: work duplication / working on unrelated tasks</p> <p>Geographical dispersion: (a) not allowing for collaborative brainstorming or for ideas' prototyping; (b) inhibiting use of pen and paper; (c) raising boundaries; (d) reducing (subconscious) visibility and speed; & (e) not allowing members to bounce off ideas, get instant feedback, and build on each other's ideas</p>	

Emotions			<p>Isolated members developing feelings of isolation</p> <p>Feelings of unhappiness: Geographical separation between University A and ESTIA24: led to the team selecting a design task they were not happy with</p> <p>Feelings of isolation inhibiting creativity when members work in isolation throughout the VDT lifecycle</p>	<p>Perceptions of distance: heterogeneity and the multidimensional subgrouping augmented distance</p>
Language		<p>Lack of language fluency leading to different expressions of creativity: acting out a concept</p>	<p>Lack of language fluency making the participants lose track</p>	<p>Lack of language fluency leading to reduced elegance of describing ideas</p>
Subgrouping		<p>Subgrouping: mitigating the negative effects of geographical dispersion & heterogeneity</p>	<p>Locational subgrouping: developing feelings of isolation; leading to imbalance</p> <p>Multidimensional subgrouping: locational, cultural, linguistic, educational</p>	

Boundaries			<p>Differences in education and culture generated boundaries that inhibited shared understanding of (a) VDT collaboration and (b) concepts and their roles, significance and rationale</p> <p>Boundaries in culture augmented the perceived distance between the two subgroups, positing lack of trust</p>	<p>Boundaries owed to education influenced the difference approaches taken toward VDT work</p>
Technology		<p>Use of CAD helping participants depict and share their ideas with the rest of the team</p> <p>Individual use of Internet helping participants identify and build on existing ideas</p>		
CMC			<p>Lack of CMC management and coordination mechanisms</p> <p>CMC reducing levels of visibility and clarity between subgroups</p> <p>Lack of pertinent ICTs for design (e.g. shared blackboard); inhibiting use of <i>pen and paper</i> techniques</p> <p>CMC not allowing for 'chemical reaction' between team members, triggering generation of ideas</p> <p>Cost- and ICT-proficiency-related factors influencing ICT selection</p>	<p>Reduced visibility causing uncertainty and impressions of unavailability</p>

Synchronicity		<p>Synchronous CMC: seen as opportunity for creativity</p> <p>Synchronous CMC: fostering a spirit of commitment & responsibility toward creativity</p>	<p>Artificiality of synchronous CMC: losing focus; missing the visual dimension; technical Issues</p> <p>Synchronous ICTs were either costly (i.e. VC) or of poor quality (i.e. Skype)</p> <p>Synchronous CMC causing an artificial environment characterized by the need to take turns, fixed participant positions and lack of spontaneity</p> <p>Artificial character of synchronicity: quality, accessibility and delays</p> <p>Synchronous CMC: slowness, time limitations and reduced productivity</p>	<p>VC constraint: time pressure</p> <p>VC purpose: coordination-related</p>
Asynchronicity	<p>Asynchronous CMC offering a flexible approach to creativity: sharing ideas irrespective of teammates' availability</p>		<p>Artificiality of asynchronous CMC: losing track due to additional activities involved in asynchronous communication</p> <p>Asynchronous ICTs were either distracting or time consuming (e.g. uploading videos on YouTube)</p> <p>Asynchronous CMC: slowness interrupting collaborative creative process</p>	

* Study 1 findings in blue; Study 2 findings in red; Study 3 findings in green

It follows from the discussion in the previous sections that there exist numerous factors that influence creativity within the VDT context of the thesis, both related to the traditional literature (Table 25, Section 9.2.2) as well as to the unique characteristics of virtuality (Table 26, Section 9.2.3). Further to these contributions, my thesis also shows which of these factors and characteristics relate to the design context (as opposed to any other VT context) more specifically, which I outline and explain in Table 27 that follows.

Table 27: Factors relating to the Design Context

	Factors	Explanation
Individual	Participation of Creative Individuals	It was found in both Studies 1 and 2 that particularly creative individuals were the ones that drove the project forward. Their presence was important in terms of (a) creativity (2 nd and 3 rd quotes, p. 153), (b) overcoming the negative effects of virtuality (1 st quote, p. 153) and leadership (discussion, p. 209)
Team	Heterogeneity	Heterogeneity is important because it is what helps designers bring different ideas to the table. However, it may also give rise to boundaries and misunderstandings in the case of highly heterogeneous VDTs (e.g. Study 2)
Task	Interest in and understanding of the design task	VDT participants must both be interested in and have a good understanding of the design task at hand (e.g. Study 2)
Technology	Visibility	It is important that designers working in VDTs have visibility over each other's progress as this is what triggers more ideas. Working virtually may result in missing part of the creative process
	Visualization	It is important that designers can visualize their ideas, be it via video-enabled ICTs, or ICTs that allow for highly synchronous collaboration with no compromises in communication speed or quality

9.3 Onward

I started this chapter with the presentation of an emergent typology of VTs, highlighting the VDT context within which the three case studies were conducted. The remainder of the chapter focused on the theoretical contributions of the thesis, bringing in the literature discussed in the earlier chapters and explaining how this thesis has contributed to it. What is more, I have identified the factors that were found to specifically relate to the design context. In the next and final chapter, Conclusion, I summarize the work presented here, and discuss the thesis' limitations and implications for research and practice.

Chapter 10: Conclusion

In this last chapter, I summarize the work presented in this thesis and recapitulate the theoretical contributions. I also outline the thesis' limitations before I close with a discussion on the implications of this thesis for research and practice.

10.1 Synopsis of the Thesis

I initiated this thesis presuming that the unique characteristics of virtuality (e.g. geographical dispersion) may influence creativity in the Virtual Team (VT) context. I selected engineering design as the empirical context, given that designers are expected to be creative and most commonly work in Virtual Design Teams (VDTs). Consistent with literature on the Social Study of Information Systems (SSIS), I borrowed selected conceptual foundations from the literature on creativity with the aim of advancing understanding of the relationship between creativity and virtuality within the VDT context. A systematic literature review on the aforementioned areas led to the development of the theoretical framework (Figure 13) which led the following Research Question (RQ):

How is creativity influenced in temporary Virtual Design Teams (VDTs)?

Given the newness of the topic under study, alongside the need for an exploratory study, I adopted an interpretive, qualitative approach that would help to improve understanding of creativity within the VDT context. I therefore conducted three case studies, each of which contributed to the theoretical framework differently. Initially, an exploratory case study contributed an impression of creativity within the VDT lifecycle, stressing, thus, the importance of developing a more robust methodological approach in order to understand creativity within the VDT lifecycle. Further, Study 1 contributed a set of factors influencing creativity, some of which were related to virtuality. Study 2 took a closer look into creativity by focusing on a single VDT in a similar educational context as Study 1. A more robust approach was employed in order to position and understand creativity within the VDT lifecycle and also a deeper examination of the relationship between virtuality and creativity was

performed. Study 3, following the same analytical lens to Study 2, focused on a single VDT in industry and contributed important accounts of creativity in VDTs in an industrial VDT context, while, in addition, it also offered findings through comparison between a Face-to-Face (F2F) and a virtual design project. Adopting the same analytical approach for all three case studies ensured consistency in terms of the generated findings. Among the main strengths of my approach are the following: (a) all VDTs were examined from start to finish, furthering extant VT literature which has taken snapshot methods, and enabling an understanding of creativity throughout the VDT lifecycle; and (b) adopting multiple data collection methods, including interviews and observations.

The findings are based on VDTs sharing the following characteristics: (a) temporary character; (b) minimal temporal dispersion; (c) use of both asynchronous and synchronous Information and Communication Technologies (ICTs); and (c) some familiarity among members. The thesis makes three theoretical contributions:

- **1st Contribution: Understanding creativity within the VDT lifecycle**

Prior work on VT creativity has been predicated on methods that did not look into creativity over time in any VT project. With my thesis, I have captured creativity throughout the VDT lifecycle of all teams under study, positioning thereby creativity within the VDT lifecycle, which I consider an important step toward understanding how creativity is influenced within this context. I have specifically found that, in line with what the design literature suggests, creativity in VDTs is significantly high during the conceptual phases of a VDT project, when VDT members are expected to generate a large number of ideas, and also at different points later in the VDT lifecycle, demonstrating that creativity is possible at various different stages throughout the VDT lifecycle. Positioning creativity within the VDT lifecycle adds to our understanding of the VT lifecycle (Bell and Kozlowski, 2002; Furst *et al.*, 2004; Hertel *et al.*, 2005) by explaining when most ideas are generated. Likewise importantly, and extending earlier work that identified stages of the VDT lifecycle, I identify four stages of the VDT lifecycle and discuss creativity

at each stage, emphasizing what is unique about the relationship between creativity and virtuality (Table 25).

- **2nd Contribution: Elicitation of factors influencing creativity in temporary VDTs**

VT studies on creativity offer a set of factors that influence creativity, which are also significant in traditional, F2F team environments. My thesis builds on this literature by explaining which factors influencing creativity in traditional contexts are transferable to, and thus significant in, the VDT context described earlier. It was found in my case studies that these factors relate to the individual, the team, the task, and lastly to the organization. What is more, these findings also show that factors influencing creativity in VDTs that do not share the characteristics detailed in Figure 42 are also significant in this context. Further to contributing an additional set of factors, and discussing their type and level of influence, my findings also contribute to the literature by exploring the individual-team-organization framework within the VDT context. In addition, they contribute to current literature as they concern VDTs using a combination of asynchronous and synchronous ICTs, contrary to Ocker's studies that were predicated on purely asynchronous VTs.

- **3rd Contribution: Creativity and the unique characteristics of virtuality**

By taking a closer look into virtuality, my thesis is the first to explore the relationship between creativity and the unique characteristics of virtuality. While most studies have identified factors influencing creativity in VTs, these are not necessarily different to the ones made in the traditional, F2F environment. With my thesis, I contribute to theory by showing how the unique characteristics that emerged in my analysis (i.e. geographical dispersion/separation; emotions; subgrouping; boundaries; technology; Computer-Mediated Communication (CMC); and lastly the synchronous and asynchronous dimensions) influence creativity in the context of VDTs (Table 27), and by making links with the concepts of continuities and discontinuities.

10.2 Limitations

As with every piece of research, this thesis carries a number of limitations which are outlined below.

First is the issue of the definition of creativity. In this thesis, creativity has been associated with the generation of ideas. Though some creativity literature is supportive of this definition (e.g. Amabile, 1996a), I must recognize that had another definition of creativity been adopted, it is likely that my findings would have been different. What is more, the focus of the work presented here has been on the generated ideas; thus, issues of novelty, usefulness and originality have not been looked at closely in this thesis.

Second is the VDT type that were examined in this thesis. The literature identifies different types of VTs, discussed in detail in Chapter 2. For instance, Townsend *et al.* (1998) speak about permanent VTs that are characterized by membership continuity. Such VTs have the opportunity to develop high levels of trust, contrary to teams that are temporarily assembled for the purpose of accomplishing a single task and are thereafter discontinued (Panteli and Duncan, 2004). The studies presented in this thesis took the case of temporary VDTs that are assembled for a single task and do not have the luxury of time or long-lasting work relationships. Thus, my findings may not be significant in polychronic VDTs.

Third, the research settings of Studies 1 and 2 have limitations concerning their relevance in industrial VDTs. On the one hand, the pedagogical character of the European Global Product Realization (EGPR), along with its impact on the students' grades, may have had implications for the participants' creativity. On the other hand, the particularly short, 24h-long duration of Study 2 introduced unprecedented challenges—e.g. fatigue, relative unwillingness to keep going—which differentiated the project from any industrial one and affected the participants' and my performance throughout the 24h. Further, though the educational environment was one whose participants were not being assessed, contrary to the EGPR, its purpose was still to educate those participating. Overall, issues of power differentials and customer expectations that may influence VDT creativity and which are common in industrial environments were absent in Studies 1 and 2.

Fourth, though Studies 1 and 2 involved global, multicultural and inter-organizational VDTs, Study 3 comprised a highly homogenous triad of professional designers with numerous similarities: nationality, language, culture, and educational background. Also, Study 3 used an intra-organizational VDT whose members were members of a single organization, thus heavily reducing diversity and heterogeneity of the team.

Where methodological limitations are concerned, there are a number of considerations. Most palpably, the qualitative character of the thesis does not allow for statistical generalizability. In other words, the findings from the three case studies are significant within their natural contexts, yet it is unknown whether their significance is transferable to other contexts. Furthermore, and as it is common in interpretive research, the research findings are subject to my own interpretations. It is also likely that, despite the richness of the gathered datasets, important issues have been unintentionally missed. For instance, though the participants in Study 3 were asked to always record their activity when they worked together as a VDT, it was felt in the analysis that some meetings had not been recorded. Similarly, due to the issues of geographical dispersion and language barriers (Study 2), it was not possible for me to capture all participants' activity. Finally, given that I am not an engineer myself, my observations were non-participant ones and may have lacked the expertise needed to understand complex design-related issues.

10.3 Implications for Research

This section is focused on the thesis' implications for future research. In particular, the limitations, outlined above, give rise to a number of opportunities for future research in the field of creativity in VDTs, which are discussed below.

It was emphasized at the outset of the thesis that the organizational level of creativity has recently attracted much academic attention in the traditional creativity literature. Though initially my aim was to study organizational issues influencing creativity as well, the fact that Studies 1 and 2 were conducted in educational contexts did not allow me to do so. My study of organizational aspects of creativity is limited to the findings from Study 3. However, Study 3 used a Small- and Medium-sized Enterprise (SME) as a research site, thus not allowing me to produce findings of significance to larger organizations. Consequently, future research should seek to attain a deeper level of understanding of organizational aspects of VDT creativity, especially by drawing on large organizations.

One of the contributions of Studies 1 and 2 was the study of global, highly heterogeneous VDTs whereby participants from different educational and national backgrounds came together, extending thereby existing literature on VT creativity, which focused on participants from the same educational setting (i.e. same university). This, however, was not the case in Study 3 whereby an industrial VDT of highly homogenous (differing in age and experience only) was examined. Moreover, the selected organization is an SME which is locally based in the southwest of England, and whose virtual collaborations are typically with clients, while its workforce is mostly collocated. It would therefore be worthwhile for future researchers to extend my findings by taking VDTs in larger organizations whose workforce is globally dispersed and heterogeneous in aspects other than age and experience (e.g. nationality, area of expertise, organization(s) to which they belong, language spoken). Such research will be of value to those partaking in global VDTs in industry.

I argued earlier that the contribution of this thesis lies in specific types of VDTs. The cases examined here involved temporary VDTs which were assembled for a specific purpose and were discontinued once the design task had been accomplished

(Jarvenpaa *et al.*, 1998). Literature on VT creativity so far (including my thesis), has been limited to the examination of temporary VT configurations. Considering, however, the different types of VDTs, future researchers should examine creativity in other types of VDTs. For example VDTs with polychronic participants, which are not disassembled upon completion of a single design task. Likewise, inter- (instead of intra-) organizational VDTs—namely VDTs whose members are affiliated to different organizations through outsourcing or other common work arrangements in industry—constitute another VDT type that deserves academic attention.

In this thesis, a qualitative approach was employed. Though, I argue, this was a germane approach to the study of creativity in VDTs, statistical generalization remains limited. Larger studies, of qualitative or quantitative character, will most likely unpack additional issues influencing VDT creativity. More quantitative studies, drawing on a larger number of research sites, will also allow for statistical generalizability. These could build on my thesis and examine whether its findings are important in a number of organizations, thereby assessing their significance in other contexts.

By following different research approaches, scholars will also be able to consider issues that have been beyond the scope of the present thesis. For example, some of the issues found to influence VDT creativity in this thesis may be similar to, or associated with, the factors influencing VDT collaboration, effectiveness or performance. It would therefore be worthwhile for researchers to employ methods that will enable them to look into causality between factors influencing creativity and factors influencing collaboration. In other words, in my thesis I studied creativity as such; not creativity as a means for improving VDT collaboration, effectiveness or performance (all of which being popular issues within the VT literature). Several other researchers who have addressed other similar issues (e.g. trust) in VT contexts have done so in order to provide suggestions for improving VT effectiveness. This has not been the case here and can well form the basis for future research.

One of the limitations characterizing Study 3 was its artificiality. Though its quasi-experimental character was what allowed me to develop a scenario whereby the same industrial design team worked on a task F2F and on another one virtually,

affording control over a number of parameters (e.g. collocation vs. distance, technology), this is also what differentiates the study from real VDT scenarios. Studies 1 and 2 were also artificially constructed, as they were initiated for the purposes of educating students, and the participants in these studies had clearly articulated tasks to accomplish in educational environments. Future research should therefore take the case of VDTs in which the participants will be free to develop their own practices and will have no limitations imposed by the researcher.

The issue of technology has been pivotal in examining not only creativity in VDTs, but also VTs in general. As the VT literature argues, technology constantly evolves and its advances form part of the reason why virtual teaming is a phenomenon that is still developing. Therefore, as technology constantly changes, so too do the dynamics within VTs. And considering that, per my findings, creativity was inhibited by the issue of speed in both synchronous and asynchronous communication in the VDTs under investigation, I would urge future researchers to centre their attention on the use of more modern synchronous ICTs that have not been the case here. This could include the use of shared whiteboards for example, that the participants in the three case studies considered potentially useful for their creativity at the team level, yet did not have the opportunity to use.

New opportunities emerge from the fact that (a) creativity was seen as idea generation, and (b) that idea-counts were used as the only method for measuring creativity within the context of this thesis. Future research could move beyond the definition adopted here and consider richer metrics of creativity. For example, taking Shah *et al.*'s (2003) suggestions, scholars could look into issues of novelty—measuring the extent to which a generated idea is uncommon or unanticipated within its context—or variety—assessing an idea in relationship with the solution space in which it was generated.

Lastly, I herein took the case of engineering design to look into VDT creativity. In order, however, to attain a better understanding of creativity in the context of VTs, I recommend that researchers move beyond the design discipline and look into VTs in other industries wherein the deployment of VTs has become commonplace,

including similar (e.g. construction engineering) and completely different domains (e.g. advertising).

Overall, the topic of creativity in VTs is a contemporary and fertile topic of research, worthy of further investigation. My immediate next step will be to publish the remaining material reported in this thesis. Subsequently, I will aim to address some of the suggestions outlined above, in particular by focusing on creativity in VTs in organizational contexts.

Discussed last in the thesis are its implications for practice.

10.4 Implications for Practice

This last section of the thesis is focused on the implications for practice. Though design served as the empirical context in this thesis, the thesis' implications are wider and the discussion that follows may be of value to practitioners from different domains, whose work requires creativity and is accomplished in VT environments. Given also that two case studies were conducted in educational settings, these findings may be of value to educators looking into the pedagogical character of creativity in VTs in education.

Practitioners need to be aware of what is important at each of the different stages of the VDT lifecycle. For VDT members with some familiarity, it may not be necessary to meet F2F early on. However, information clarity is important for understanding the design task. It is also important for the VDT to meet using synchronous ICTs and exchange information ensuring that the task at hand is understood. Geographical isolation enhances creativity as it gives space to VDT members to understand and explore the market with minimal distractions at the early stages. At the conceptual stages it is important that the selected ICTs allow for immediate feedback so that members can build on each other's ideas. Frequent communication is also important as isolation can inhibit creativity at this stage. Heterogeneous VDTs have the potential for more creativity, yet attention should be paid to boundaries created by differences in background. At the later stages, practitioners should attempt to meet F2F as this has been found to give rise to more ideas. VDT members partaking in multiple projects should not compromise their creativity, when that is needed, due to external commitments.

My findings hint at certain characteristics that individuals partaking in VDTs should have. These individual characteristics—varying from excellent communication and organizational skills through to relevant knowledge, technological proficiency and leadership potential—are necessary if VDTs are expected to be creative. As therefore, VDT managers should recruit participants with these individual characteristics if aiming for high creativity in their VDTs.

Traditional management theories were found to be pertinent to managing creativity in VDTs. For instance, both centred and democratic leadership styles that have been discussed in the traditional creativity literature were found to be significant in my thesis, encouraging creativity throughout the VDT lifecycle. Thus, I recommend that VDT managers aiming for high degrees of creativity should still follow practices emanating from the management of traditional teams.

Most importantly, practitioners should be conscious about the relationship between creativity and the unique characteristics of virtuality in their VDTs. For instance, if their VDTs comprise collocated subgroups, these can play a positive or a negative role for creativity, depending on how they are managed. It is important that, if collocated subgroups emerge, they should not be completely dissimilar to the rest of the VDT (in more than one or two aspects) because this will impact the team dynamics overall and it will not be possible for the team to be creative at the team level. On the other hand, and subject to pertinent management, subgroups can drive a VDT's creativity forward.

What is more, it is important that VDTs in industry have access to both asynchronous and synchronous ICTs, as each type was found to serve a different purpose for creativity. On the one hand, the use of asynchronous ICTs is important to VDTs with high degrees of temporal dispersion (e.g. global VDTs) as they enable VDT members to be creative regardless of their teammates' availability, and also to document their ideas and keep track of the creative process. On the other hand, synchronous can be helpful for attaining creativity at the team level, similarly to a F2F environment. In both cases, the selected ICTs should be pertinent to the task(s) at hand, and practitioners should be able to ensure that their management practices mitigate the potential disadvantages of both types of ICTs (e.g. emergence of boundaries raising visibility issues, slowing down of the creativity process).

Geographical dispersion can inhibit creativity in VDTs significantly. Managers should therefore ensure to have the right systems in place to prevent geographical dispersion from influencing creativity in a negative manner. These could include ensuring (a) a VDT works together as one team; (b) ICTs are used to soften the

negative effects of geographical dispersion, e.g. part of the VDT missing part of the creativity process; (c) coordination is in place so that the VDT does not duplicate the same work or works on unrelated tasks; (d) all VDT members are happy regardless of where they are based. Notwithstanding these, being separated from the rest of the VDT may also enhance creativity when, for example, no direct pressure is felt by some members, due to them being physically separated from others.

My findings at the organizational context suggest that organizational aspects can act as enhancers of creativity in a VDT but not all organizational factors are transferable from the F2F to the virtual context. For instance, an organization's approach of freedom and openness at the early stages of the VDT lifecycle can influence creativity positively regardless of environment (F2F or virtual). However, there exist certain practices that may not be easily transferable, such as the development of a shared wall space which can be used for better visualization of generated ideas as well as for ideas' sharing and tracking. As such, practitioners are advised to employ tools that will allow them to successfully create similar virtual platforms which can satisfy these purposes without making compromises on issues of communication quality and speed.

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Appendices

Appendix A: EGPR First Contact and Approval Email Excerpt

This is an (anonymized) excerpt of the email that was sent to me in March 2010 by one of the EGPR organizers as a response to my request to use the EGPR as a research site for my PhD research:

"Hi Petros,

Today I informed our partner universities in EGPR project. They all agree with your involvement in the project. However, there are two industrial partner companies that also have to be asked, especially regarding the confidentiality of information that will be developed during the project. I will forward our correspondence to my colleagues in Ljubljana, and they will consult these two companies. One company already asked all persons involved in project to sign the "Non-disclosure agreement". I hope we will get their feedback soon.

[...]

Kind regards,

[Anonymous]" (an EGPR organizer)

Appendix B: EGPR Non-Disclosure Agreement (NDA) Form

Below I copy-paste an excerpt of the NDA Form I signed accepting the terms and conditions (outlines in it) set by the industrial partners that were involved in the EGPR the year my study was conducted. For anonymity purposes, I do not provide the actual form signed and I also disguise the industrial partners' names:

*"EGPR Member and [industrial partner] consider working together in the following field:
International student research and development project of a new product for [industrial partner] called EGPR (European Global Product Realization)*

To assess a cooperation project, [industrial partner] will disclose confidential information of all kinds and hold confidential discussions. For the purpose of preventing the unauthorised disclosure of confidential information, the parties agree to enter into the following Agreement:

- 1. EGPR Member hereby agrees to keep confidential and not to disclose to third parties any information or material received from [industrial partner] and/or information or material that has become known to EGPR Member in the course of their cooperation; such information or material includes business and technical information, drawings, sketches, technical documents and samples as well as any intellectual property inferred directly therefrom.*
- 2. Information received shall be used only for the purpose of examining a potential cooperation commitment or engaging in such cooperation. Any such cooperation shall be subject to a separate agreement which, when signed and effective, shall amend and/or replace the present Agreement.*
- 3. The following shall not be deemed to be third parties: companies affiliated to the parties hereto after they have been committed to nondisclosure restrictions. The receiving party's obligations shall likewise be binding on its representatives.*
- 4. The receiving party's obligations under this Agreement do not extend to information that is:
(a) publicly known at the time of disclosure or
(b) known to the receiving party at the time of disclosure;
(c) subsequently becomes publicly known through no fault of the receiving party;
(d) learned by the receiving party through legitimate means other than from the disclosing party and without any limitation concerning its confidentiality or use.*

Exclusions from the non-disclosure obligation also extend to disclosures based on public corporate obligations.

Furnishing proof of the presence of aforementioned exclusionary circumstances shall be incumbent on the receiving party.

5. *The parties shall keep a record of each exchange of information (see sample in appendix to the present Agreement), stating the content of the information exchange, including a list of any documents and samples received; this record shall require the signature of both parties and all persons involved in the discussions. In the absence of such records, all other provisions of the present Agreement shall remain effective.*
6. *EGPR Member recognizes that all records, notes, and other written, printed, or tangible materials received from [industrial partner] shall be used solely for the purposes of this Agreement and shall not, without prior written approval of [industrial partner], use such confidential information for its own commercial benefit. By disclosing information, [industrial partner] shall not grant any licence or the like.*

Accordingly, [industrial partner] shall retain the unrestricted property rights to its own developments and experience (including the right to file applications for intellectual property protection at home and abroad); disclosure of confidential information, related findings and experience shall not entitle EGPR Member to use this for its own commercial benefit or to file applications for intellectual property protection. Any such use shall require a separate contractual agreement between the parties hereto.
7. *EGPR Member shall ensure the safekeeping of all records, notes, and other written, printed, or tangible materials. These shall be returned to [industrial partner] immediately on written request by the latter. Such records, notes, and other written, printed, or tangible materials shall also be immediately returned if the envisaged cooperation does not materialise for whatever reason. EGPR Member shall not to retain any form of copy of such information.*
8. *The term of the present Agreement shall begin with its signature by both parties and apply for the duration of information exchange. The obligations under this Agreement shall end 5 (five) years after termination of the present non-disclosure Agreement.*
9. *Any amendments to the present Agreement shall be made in writing. This Agreement is subject to the jurisdiction of the Federal Republic of Germany. The place of jurisdiction shall be Munich.*
10. *Should any provision of this Agreement be ineffective or become so in the future, the other provisions of this Agreement shall remain unaffected. The parties shall replace any invalid provision by another provision which is closest to achieving the original intent of the invalid provision."*

Appendix C: ESTIA24 Website Links

Below are the weblinks associated with ESTIA24:

<http://biarritz.monagenceca.com/index.php?post/2010/10/12/24H-de-l-innovation-a-l-ESTIA>

<http://www.antic-paysbasque.com/index.php?2010/09/27/301-entreprises-developpez-rapidement-et-gratuitement-vos-projets-creatifs-et-innovants-en-24h-chrono>

<http://www.sudouest.fr/2010/10/22/24-heures-d-emotion-218088-8.php>

http://www.24h.estia.fr/sauv_24_guillaume/Public/img/presse/24h_innovation_SU DOUEST_22oct2010.jpg

Appendix D: Participants' Ethics and Consent Forms

This is a sample of one of the consent forms signed by the studies' participants:

Project: Meeting Human Subjects

Consent Form

Researcher	Petros Charalotiis	Position (UGPGRO)
Supervisor	Dr. Elias Dekoninck	
Project Title	Creativity in Virtual Design Teams	
Project Number (if applicable)		

Each person participating in the study should complete the following:

	Yes	No
1. Have you read the information sheet?	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2. Have you had the opportunity to ask for more information about the study?	<input checked="" type="checkbox"/>	<input type="checkbox"/>
3. Are you happy with the answers to any questions you had, if any?	<input checked="" type="checkbox"/>	<input type="checkbox"/>
4. Do you understand that you are free to withdraw from the study at any time?	<input checked="" type="checkbox"/>	<input type="checkbox"/>
5. Do you agree to take part in this study?	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Signed (Participant):

Print Name (Participant): Date: 22/10/2010

Appendix E: Communications with ESTIA24 Lead Organizer

The email below was sent to me in October 2010 by the ESTIA24 lead organizer to welcome me to participate in the project as a researcher:

"Dear Petros,

It will be a pleasure to welcome you during the 24h event. For your information, the previous editions have been observed and studied by different researchers: analysis of team's presentation, analysis of the 24h work of one team, analysis of collaborative tools...

Every year, there are 2 Grenoble teams that work at distance and collaborate with 2 delegates in Biarritz and the rest of the team are in Grenoble. (But I think they use French to exchange among them)

Last year, Spanish, Italian, and USA teams worked in their respective country but there were not any representative in Biarritz (and so no distant collaboration). They "just" present their work with videoconference at the end of the 24h.

So I think that the 24h can be a good opportunity for you if you propose to come with one or two students that will be in Biarritz and organise a team at distance at Bath? then you could observe distant collaboration, virtual exchange...

If I have similar proposition from other universities, I will keep you informed

Many thanks again for your interest (and many thanks also to Elies)

[Organizer's name]"

Appendix F: ESTIA24 Manual Coding of VDT Lifecycle and Ideas

This is an excerpt of the flipchart papers that were used to manually code the ideas and issues that were found to be associated with creativity in the ESTIA24 VDT. The ideas were written down on post-it notes that were later stuck on the right place on the flipchart papers:



Appendix G: Visual Analysis of Studies 2 and 3

Here I provide excerpts of the Excel spreadsheets that emerged from my visual analysis of Studies 2 and 3. The colour coding is explained in Appendix H:

Study 2 Visual Analysis

[illegible]

Study 3 Visual Analysis

DAY	Day 11	Day 12	Day 13	Day 14	Day 15	Day 16	Day 17
	Skype tech problem	accessing Prezi	reaching G	clip bracket concept	S: are you watching my screen?	L-shape for securing window	accessing emails and files online
	unsuccessful attempts on Skype	organizing work	locating progress on Dropbox	modeling up thoughts	G: you disappeared from Prezi	Skype video sharing for explanations	fixed-in frame
	Skype tech problem	how Prezi works	aluminium idea	sharing sketches	S: difficulty loading up stuff	Twist locks	incorporating cutter in existing frame
	software use	how do I follow P	locating bubbles	org next meeting	S: converting CAD to PDF and uploading to Prezi	Corner release mechanism	PVC wooden boards
	member availability	pull-down blind	choosing medium	org search and work distribution	S: Prezi is not letting put more stuff on it	Twist on the rod	rolling cylinder
	content organization	handle	visibility issues on Prezi	selecting medium	merging circular and magnetic middle section idea	Flip flop collar	screws rather than groove
	software selection	rail attachment	Avatar issues on Prezi	magnetic assembly	bracket thickness	bike metal rod	frame lifts
	email for sharing	air-tight	glass stairs	modeling up existing ideas	seal on bracket to increase flexibility	frame contact with glass	Skype issue
	time issues and coordination	cylinder	steel idea	text from Gary suggesting meeting tomorrow at 1100	magnet securing glazing	rubber on glazing	rolling glazing
	prezi details	elastic material	compressible seal	suggestion: what are you doing now? S-P	rubber washing either side of glazing	attachable frame	adjustable roller brackets
	connection problems on Skype	ratchet	strong magnets	getting drawings ready this evening	Skype echoing	push-fit frame	circle telescopic frame
	web-based apps not working	light weight	glued bracket	target to find materials following morning	U-shaped flexible channels	bolted frame	telescopic arms between corners
	locating Prezi	multiple glazing panel	perspex idea	work out feasibility of materials	magnets in combination with other material	springy push-fit mechanism	technical problem moving around Prezi
	working live simultaneously	fixed position	circular brackets	choose materials and check with Gary	compressing seals	friction fit	uploading docs: photo or scan
	rigid solution	magnetic tape	cork idea	scan existing hand-written drawings and put on Prezi [S]	elastic band around four corners	drawing and showing on camera	adapting or attaching frame
	locating Prezi	iMac idea	glass and cork combined idea	2	circular wall bracket	metal cylinder	flat clip
	solid glazing	use room pressure	circular magnets with seal		inflatable panel	plastic grooves	deflective extrusion
	reusable materials	interruption	transferring files	Eden project / Aquatic centre / Gatwick north terminal	air pump idea	call interruption	drawing concepts ON Prezi
	product and service	chair noise	accessing Prezi contents		Skype echoing	V2V Skype instead	springy ramp
	unclear conversations	perplex material	visibility issues on Prezi		rigid frame	15	drawing concepts ON Prezi
	how to capture ideas	rod recyclable	storing content for sharing		transparent material to attach to frame		plastic rib
	aluminium frame	plastic panels	calling G on phone		foil idea		can't access uploaded pics
	accessing Prezi	storage	troublesome 3way Skype		transparent, multilayer material		difficulty drawing with mouse
	Prezi content editing	seal	Skype echoing		Skype echoing		how to lead the presentation
	email for explanations	runners	taking time to draw on CAD		sandwich layer: double glazing plus seal		flexible lip
	copying-pasting on Prezi issues	transparent	org what to draw up		Skype echoing		incorporate wood section
	grouping content on Prezi	bigger panels	avoiding details when drawing on Prezi		one large framework		paint wood section
	how to make it smaller	rubber inclusion	Skype echoing		sandwich structure idea		pre-painted MDF wood
	thermal conductivity	re-assembled	medium selection		geometrical panel		skype interruption
	flexible plastic materials	no glazing	org next meeting		inflatable and artistic patent		recalling
	optical quality materials	draft exclusion mechanism	Skype crashing		chunky frame		different colours
	polycarbonate	flexible frame to pick up window shape	11		Skype echoing		lockable windows
	edges	base of corner			Skype echoing		rotational lock
	PMA fibers	skating board idea			Skype echoing		telescopic perimeter
	simultaneous viewing on Prezi	rectangular plate with slotted arms			Started to use mics to prevent echoing		G: laptop battery running down
	complete service	pop-out frame structure			G: Can't put things on Prezi		
	durability and lasting	lockable frame			G: Can't use it full screen		
	temporary work station	Skype echoing			G: Can't access part of the screen info		
	roman glass	leave and reconnect			P: Prezi getting big and not responding		
	cutter	melinex system			G: How to create frames on Prezi		
	guillotine	rollable material			G: Difficulty inserting images into Prezi		

Appendix H: Colours Explaining Appendix G

The colours used in Appendix G are explained here. Three categories of colours were used to classify: (a) findings (to distinguish design ideas from management issues); (b) the communication media used (varying from Skype and email to complete absence of communication media, e.g. F2F collaboration within each subgroup); and (c) data source (representing the different sources that the data emerged from):

FINDINGS

	DESIGN IDEAS
	MANAGEMENT ISSUES

COMMUNICATION MEDIUM

	F2F (in-subgroup)
	VIDEO CONFERENCE (VC)
	SKYPE VC
	SKYPE IM
	EMAIL
	YOUTUBE
	INDIVIDUAL WORK

DATA SOURCE

	VIDEO CAMERA
	SKYPE RECORDS
	PHOTOGRAPHIC MATERIAL
	PANOPTO